

# **Reinvestment & Risk: Skill acquisition in high-risk sports**

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## Abstract

The unique focus of this thesis is to examine skill acquisition within high-risk sports, where threat of physical harm may be potentially the primary stressor. Research to date has examined the beneficial effects of applying various implicit and explicit-based learning interventions upon stressful situations, whereby explicitly acquired skills deteriorate. This is largely due to a phenomenon understood as reinvestment, whereby athletes will internally direct attention towards their actions, ultimately having a debilitating effect on performance. The unique aspect of risk within sports such as skateboarding, provides a potential avenue to understand if the benefits of implicit-based learning strategies can extend to a wider collection of ever-expanding high-risk sports (e.g. BMX, Snowboarding, Formula 1). Minimal research to date has focused on this unique culture of high-risk sport and the mechanisms by which skill acquisition occurs.

Experimental study 1 examined reinvestment propensity of high-risk sports athletes (e.g. skateboarding) against low-risk counterparts (e.g. golf) across the learning spectrum of novice, intermediate and experienced. Performer status was also examined to identify any differences in the propensity to reinvest between athletes of amateur and professional status. Low-risk athletes displayed a decrease in the propensity to reinvest as they progressed from novice to a more experienced level. Furthermore, results confirmed that high-risk athletes displayed a unique propensity to reinvest in their movements when compared to low-risk counterparts. This (high-risk athletes reinvesting to a greater extent) represents an original contribution to the current debate on the behavioural characteristics in high-risk athletes.

The sensation seeking trait, synonymous with risk, was also measured to highlight a unique differentiating aspect between high and low-risk sports. Results confirmed that this trait was significantly higher within high-risk athletes in comparison to low-risk counterparts.

The methodologies employed across experimental studies 2, 3, and 4 compared various implicit-based learning interventions (analogy & guided discovery) against explicit instruction. These studies incorporated participants defined as novice (study 2), experienced amateur (study 3) and professional high-risk athletes (study 4). Results were similar at all levels of performance, whereby implicit-based learning interventions demonstrated significantly superior performance and minimal reductions in reinvestment propensity.

The thesis also aimed to contribute to the debate between the effectiveness of video versus live demonstrations of skill acquisition within the experimental studies. No support could be identified in favour of using live as opposed to video demonstrations or vice versa, indicating both are viable for coaching delivery.

The theoretical implications of the results in the current thesis are discussed within the framework of working memory and the wider application to other unique learning methodologies which feature risk from physical harm as a potential stressor.

## Contents

Abstract	i
Contents	ii
List of Tables	v
List of Figures	vi
List of Appendices	xi
Acknowledgements	xii
 Chapter 1 - Introduction	 1
 Chapter 2 - Literature Review	 14
2.1 Anxiety and successful performance	14
2.2 Reinvesting in the individuals' responses	40
2.3 Implicit / Explicit learning strategies	51
2.4 Observational learning	65
2.5 Design considerations within learning paradigms	76
 Chapter 3 - Experimental Study 1	 88
<i>“Reinvestment propensity and sensation seeking tendencies in various skill levels in both high and low-risk sports”</i>	
3.1 The role of Sensation Seeking in experimental study 1	89
3.1.1 Introduction	89
3.1.2 Methodology	97
3.1.3 Results	100
3.1.4 Discussion	105

3.1.5 Summary	109
3.2 The role of Reinvestment in experimental study 1	110
3.2.1 Introduction	110
3.2.2 Methodology	118
3.2.3 Results	120
3.2.4 Discussion	124
3.2.5 Summary	128
Chapter 4 - Experimental Study 2	130
<i>“Skill acquisition techniques in high-risk sports at the novice stage of learning”</i>	
4.1 Introduction	130
4.2 Methodology	132
4.3 Results	139
4.4 Discussion	155
Chapter 5 - Experimental Study 3	161
<i>“The effect of an Analogy based learning strategy in experienced amateur high-risk sports”</i>	
5.1 Introduction	161
5.2 Methodology	164
5.3 Results	171
5.4 Discussion	188
Chapter 6 - Experimental Study 4	193
<i>“The effect of an Analogy based learning strategy in professional high-risk sports”</i>	
6.1 Introduction	193

6.2 Methodology	198
6.3 Results	205
6.4 Discussion	222
Chapter 7 - General Discussion	229
References	253

**List of Tables**

Table 1	98 & 119
<i>“Sample sizes post-categorisation based on variables; sport, experience and status (experimental study 1)”</i>	
Table 2	133
<i>“Key demographic data for all participants in experimental study 2”</i>	
Table 3	165
<i>“Key demographic data for all participants in study 3”</i>	
Table 4	198
<i>“Key demographic data for all participants in study 4”</i>	

## List of Figures

Figure 1	101
<p><i>“Mean total score of Sensation Seeking Scale V (SSSV) (Zuckerman, 1978) for all ‘experience’ groups; High-risk Novice (HR NOV), High-risk Intermediate (HR INTER), High-risk Expert (HR EXP), Low-risk Novice (LR NOV), Low-risk Intermediate (LR INTER), Low-risk Expert (LR EXP) in experimental study 1”</i></p>	
Figure 2	102
<p><i>“Mean score for sub-scales Thrill &amp; Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS) and Disinhibition (Dis) for all ‘experience’ groups; High-risk Novice (HR NOV), High-risk Intermediate (HR INTER), High-risk Expert (HR EXP), Low-risk Novice (LR NOV), Low-risk Intermediate (LR INTER), Low-risk Expert (LR EXP) in experimental study 1.”</i></p>	
Figure 3	104
<p><i>“Mean total score for Sensation Seeking Scale V (SSSV) (Zuckerman 1979) for all ‘status’ groups; High-risk Amateur (HR AM), High-risk Professional (HR PRO), Low-risk Amateur (LR AM), Low-risk Professional (LR PRO) in study 1”</i></p>	
Figure 4	105
<p><i>“Mean score for sub-scales: Thrill &amp; Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS) and Disinhibition (Dis) for all ‘status’ groups; High-risk Amateur (HR AM), High-risk Professional (HR PRO), Low-risk Amateur (LR AM), Low-risk Professional (LR PRO) in experimental study 1.”</i></p>	
Figure 5	121
<p><i>“Mean total score for Movement Specific Reinvestment Scale (MSRS) for all ‘experience’ groups; High-risk Novice (HR NOV), High-risk Intermediate (HR INTER), High-risk Expert (HR EXP), Low-risk Novice (LR NOV), Low-risk Intermediate (LR INTER), Low-risk Expert (LR EXP) in experimental study 1.”</i></p>	

Figure 6 122

*“Mean score for sub-scales: Movement Self-Consciousness (MS-C) and Conscious Motor Processing for all ‘experience’ groups ; High-risk Novice (HR NOV), High-risk Intermediate (HR INTER), High-risk Expert (HR EXP), Low-risk Novice (LR NOV), Low-risk Intermediate (LR INTER), Low-risk Expert (LR EXP) in experimental study 1.”*

Figure 7 123

*“Mean total score of Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) for all ‘status’ groups; High-risk Amateur (HR AM), High-risk Professional (HR PRO), Low-risk Amateur (LR AM), Low-risk Professional (LR PRO) in experimental study 1.”*

Figure 8 124

*“Mean score for sub-scales: Movement Self-Consciousness (MS-C) and Conscious Motor Processing for all ‘status’ groups; High-risk Amateur (HR AM), High-risk Professional (HR PRO), Low-risk Amateur (LR AM), Low-risk Professional (LR PRO) in experimental study 1.”*

Figure 9 140

*“Mean subjective scoring across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control”*

Figure 10 142

*“Mean kinematic analysis for the angles of skateboard at peak height across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control”*

Figure 11 144

*“Mean number of explicit rules recalled across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control”*



## Figure 12

146

*“Mean total score for the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

## Figure 13

148

*“Mean scores from the Conscious Motor Processing subscale (CMP) of the Movement Specific Reinvestment Scale (Masters et al, 2005), across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control”*

## Figure 14

150

*“Mean scores from the Movement Self-Consciousness subscale (MS-C) of the Movement Specific Reinvestment Scale (Masters et al, 2005), across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control”*

## Figure 15

152

*“Mean total score from the Sensation Seeking Scale V (SSSV) (Zuckerman, 1978), across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control”*

## Figure 16

173

*“Mean subjective analysis across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

## Figure 17

175

*“Mean angle of skateboard at optimal height of skill execution across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 18

177

*“Mean number of explicit rules recalled across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control”*

Figure 19

179

*“Mean total score of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 20

181

*“Mean score of the Conscious Motor Processing sub-scale (CMP) of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 21

183

*“Mean score of the Movement Self-Consciousness sub-scale (MS-C) of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 22

185

*“Mean total score for the Sensation Seeking Scale V (SSSV) (Zuckerman, 1978), across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 23

207

*“Mean subjective analysis score across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 24

209

*“Mean angle of skateboard at optimal height of skill execution across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 25

211

*“Mean number of explicit rules recalled across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 26

213

*“Mean total score of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 27

215

*“Mean score of the Conscious Motor Processing sub-scale (CMP) of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 28

217

*“Mean score of the Movement Self-Consciousness sub-scale (MS-C) of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

Figure 29

219

*“Mean total score for the Sensation Seeking Scale V (SSSV) (Zuckerman, 1978), across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.”*

## List of Appendices

Appendix 1 -	Movement Specific Reinvestment Scale	289
Appendix 2 -	Sensation Seeking Scale V	290
Appendix 3 -	Consent form	294
Appendix 4 -	Instructions for Guided Discovery groups in experimental study 2 (“Ollie”)	295
Appendix 5 -	Instructions for Explicit learning groups in experimental study 2 (“Ollie”)	295
Appendix 6 -	Instructions for Explicit learning groups in experimental study 3 (“Backside180 Kickflip”)	296
Appendix 7 -	Instructions for Explicit learning groups in experimental study 4 (“360 Nollie Laserflip”)	297

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# Chapter 1

## Introduction

*"They [high-risk sport athletes] are a different breed of human being. To perform in these sports, you have to think and approach the situation unlike any other. Everybody else has that self-preservation mechanism in their mind for being fearless. In this kind of sport, you can't give in to that, you can't forget about it. All you can do is persevere, whatever the risk."*

Danny Way (2012)

X-Games gold medallist (5x)

During the 2018 winter Olympic games held in PyeongChang, South Korea, Shaun White won the gold medal for men's halfpipe in snowboarding with an unprecedented demonstration of skill, coordination, complexity and risk. The performance included back-to-back 1440° spinning skill variations with consecutive 1260° back-to-back reversed variations, including record heights of over 12 feet in the air. Scoring was attributed to the complexity and style of performance, whilst also considering the risk involved by attempting such a run. This is a prime example of the extent to which high-risk sports such as snowboarding evolve, requiring performers to constantly increase the risk factor of their performance.

Modernised traditional sports such as Basketball, Golf, Tennis, Football, and Ice Hockey have benefitted substantially from becoming professionally developed. Sports such as these have grown in popularity in the last century

and encompass a wide range of participants, spectators and business from around the world. A more recent development within sport is the emergence of the high-risk sporting community. This concept is understood as a parallel to traditional sports, complete with its own stars, history, language, culture and sensibility (Browne, 2005). High-risk sports can be defined as sports whereby participation possesses a high probability of serious injury or death as a consequence of practicing the sport (Zuckerman, 1983). Breivik (1999) proposed a similar definition of “all sports where you have to reckon with the possibility of serious injury or death as an inherent part of the activity” (p. 10). Problematically, these definitions lack clarity, as it is failure to perform in the sport correctly that can result in this probability to suffer serious harm, and not simply by practicing. Various other names have been associated with high-risk sports through the sporting community, such as Extreme sports or Action sports (Browne, 2005). Brymer (2005) defines Extreme sports as independent activities where a mismanaged mistake or accident would most likely be fatal. Successful performance removes the inherent risk associated with these sports. This sense of regulating emotions such as fear and accomplishment are the motivating factor within high-risk sports (Barlow et al, 2013; Cazenave et al, 2010; Woodman et al, 2008). Woodman et al (2013) stated that high-risk sports participants can engage in precautionary behaviours to minimise risk. This distinction will become more apparent throughout the course of this thesis regarding skill acquisition and a cognitive behaviour known as reinvestment.

Commercially, high-risk sports encompass the Action sports industry and have experienced a significant rise in popularity, exposure, media coverage, professional development and education since its humble

beginnings over three decades ago (Browne, 2005). The current thesis is concerned with education by aiming to identify the most effective means of facilitating skill acquisition. Participation rates within action sports have grown exponentially over the last three decades (Thorpe & Dumont, 2018; Pain & Pain, 2005). It is estimated there are around 14 million skateboarding athletes worldwide (Thorpe & Dumont, 2018) and around 86 million individuals participating in action sports (Ostrowski, 2002) cementing this unique category of sports into a billion-dollar industry (Browne, 2005). The industry has developed its own international competitions, attracting millions of spectators on a global scale. These include the X-games championships dating back to 1995, to more recent international touring developments such as Street League Skateboarding (SLS) and Dew Tour. These international competitions for professional athletes were created as an alternative to the Olympic movement until recently (Dyrdek, 2012). High-risk sports have gradually become included in the Olympics over the past few decades. Snowboarding was first introduced at the 1998 winter games held in Nagano, Japan, whilst BMX (Bicycle Motocross) racing made its debut at the 2008 summer Beijing games. At the Youth Olympic games 2014, skateboarding made its Olympic debut on the smaller stage, with exceptional success being well received by spectators and the Olympic community (IOC, 2018). In the upcoming 2020 Tokyo Olympic Games, another two quintessential high-risk sports in the form of surfing and skateboarding will be included within the games (IOC, 2018).

Witnessing the elite performances during these professional competitions inspires and motivates the next generation to achieve. Camp Woodward is the first extreme sports training camp and was opened in 1970 and has now



expanded to include over a dozen sport-specific training and educational facilities. Facilities such as Camp Woodward are similar in design and purpose for high-risk sports as Lilleshall Hall operates for football under Sport England. Experienced instructors give tutelage with guest appearances from professional athletes. This is also evident at other instructional facilities such as the Element YMCA skate-camp, along with countless independent skate-parks across USA, Canada and UK. These institutions operate from 'grass roots' to highly experienced and professional levels employing participant development programs during the summer months. Such programs are aimed at catering to the tuition of high-risk sports to all abilities. To date, little if any research exists regarding the most effective instructional methods to educate athletes of high-risk sports, despite the existence of a myriad of research identifying the participants of study as a 'unique sporting community' (Brymer & Schweitzer, 2013).

Research has focussed on high-risk / extreme sports concluding that factors such as risk, danger, the "adrenaline junkie" stereotype are all inherently associated with participation (Monasterio et al, 2012; Self et al, 2007; Olivier, 2006; Simon, 2002; Rinehart, 2000). The literature is divided between the notion as to whether participating is the result of a healthy desire or a threatening flaw. The main theoretical perspectives derive from both psychological and sociological research. Many of the sociological explanations see participation as a negative consequence to personality traits (Self et al, 2007; Breivik, 1996) and social acceptance (Allman et al, 2009; Laurendeau, 2008). Complimentary research supports the idea that although participating within high-risk sports may be dangerous, it allows for the discovery of

significant benefits from a phenomenological perspective (Brymer & Schweitzer, 2017; Brymer & Schweitzer 2013; Brymer & Gray, 2010; 2009; Brymer, 2010).

Research from a psychological focus encompasses the traditional psychoanalysis perspective (Hunt, 1996), to personality theory 'Type T' (Self et al, 2007), personality trait, sensation seeking (Guszkowska & B`oldak, 2010; Zuckerman, 2007; Deihm & Armatus, 2004; Breivik, 1996) and emotional self-regulation (Barlow et al, 2015; Barlow et al, 2013; Cazenave et al, 2010; Woodman et al, 2010; 2009; 2008). All of the approaches identify participation and therefore the participants, as different compared to other sporting participants. This suggests that the high-risk aspect of the sport creates an avenue for a unique form of participant regarding the psychology of the athlete. The type T personality identifies the athletes' need for uncertainty, novelty, ambiguity, variety, and predictability (Farely, 1991). Whilst participation under this approach is viewed as a deviant personality trait (Self et al, 2007), other approaches identify the need for novelty, stimulation, or emotional control from an abnormal but neutral perspective.

Sensation seeking identifies similar trends to personality T, such as the necessity for novel stimulation and boredom susceptibility. Emotional regulation refers to actions that modulate the intensity, type or duration of emotion, and the ways in how they are experienced and expressed (Gross & Thompson, 2007; Gross 2002; Thompson, 1994). The high-risk nature of these sports can understandably elicit heightened emotions such as anxiety or fear. Contrary to popular media belief, research has shown that these athletes experience fear as a core response and are not fearless (Brymer & Schweitzer, 2012). Regulating emotions such as fear through participating in high-risk

sports has shown to provide an opportunity to control the actions of the performance (Brymer & Schweitzer, 2012).

A recent scoping review has identified a severe lack of empirical knowledge regarding the learning of action sports participants (Ellmer et al, 2019). The review covered a total of 78 empirical publications but showed no research regarding the context of instructional techniques concerning this thesis (e.g. reinvestment/implicit learning). Ellmer et al (2019) did identify several themes pertinent to the current investigation. Fear was observed to impact performance provided it could not be managed or overcome (Hawxwell et al 2018; Ellmer & Rynne, 2016; Evin et al, 2014; Kirk & MacPhail, 2002).

Haines et al (2010), utilising ethnographic research methods, identified that participants within skateboarding expressed an acceptance of the inherent risk (of injury) as pivotal in their search for freedom. This aspect of 'being free' has been shown to be 'the single most important value expressed by the participants' (Haines et al, 2010). Rising to the challenge of successfully acquiring the skill (landing the trick) was shown to involve a progressive feedback loop whereby mastering the skill in spite of the risk from failure would compel the learner to seek out another challenge and experience the sense of freedom. Becoming free of the inhibition and moving beyond the restrictions upheld by a sense of self-preservation is of key concern (Haines et al, 2010). A risk-benefit analysis was identified by Haines et al (2010) as a core value of skateboarding culture, whereby the analysis involves the evaluation of risk from injury juxtaposed to the experiential price of progression and freedom. Risk appraisal is a central construct of sensation seeking theory proposed by

Zuckerman (2006) regarding personality traits and is discussed further, later in this chapter.

The concept of risk is defined within this context of physical risk-taking and a risk-benefit ratio, whereby the chance of severe injury/harm is weighed against the anticipated positive outcomes by success. This is not to argue that other sports do not involve the potential for physical harm. Contact sports (e.g. rugby or ice hockey) and combat sports (e.g. mixed martial arts or boxing) condone a level of physicality whereby injury is an acceptable possibility. However, there are rules and regulations to prioritise the safety of the player. Specific codes of conduct enforced by officials to minimise the risk of severe injury, with subsequent consequences for acting in what is classified as unsafe in those sports to allow for fair competition.

The risk of these sports involves the aspect of human play in the context of Gadamer (1965). Many high-risk sports take place within nature and the unpredictable aspect of environment or weather can play a significant influential factor within performance (Breivik, 2011). Gadamer (1965) suggests the notion that play within high-risk sports extends beyond human play into the natural environment. Human interaction within nature is a two-way process, as whilst most high-risk sports are being played within nature, nature is simultaneously playing with the participant (Breivik, 2011). There is no rule or regulation governing nature to act, allowing for a deeper state of play where risk is considered heightened and thus more dangerous (Breivik, 2011). Heidegger (1962) defines risk as the confrontation of danger with the possibility of death. This reminder of mortality and resoluteness to move beyond the threat (experienced by high-risk athletes) is considered to be living a life of

authenticity and categorised as being honest to oneself (Heidegger, 1962). This notion of authentic living has been argued as the pursuit of high-risk athletes (Breivik, 2010) and is echoed within the skateboarding occupational culture identified as a sense of freedom (Haines et al, 2010).

This euphoric sense of freedom has been viewed as a means of promoting psychological and physical well-being within other motives for why participation occurs within this unique culture (Brymer & Schweitzer, 2013; Lima et al, 2011; Brymer & Gray, 2009; Brymer & Oades, 2009). Research has outlined participation within action adventure sports (AAS) (including high-risk activities, i.e. skateboarding) allows the opportunity to provide multiple benefits. Firstly, fulfilment of psychological needs of autonomy, competency and connection (Clough et al, 2016), increased positive experiences of psychological resilience and self-efficacy (Brymer & Schweitzer, 2013; Mackenzie et al, 2011; Brymer & Gray, 2009). Secondly the opportunity to overcome a challenge (Kerr & Mackenzie, 2012) and the ability to experience intense emotions (Brymer & Schweitzer, 2012). Finally, a sense of increased connection to nature (Brymer & Schweitzer, 2015; Brymer et al, 2009; Brymer, 2009) and increased physical activity (Clough et al, 2016; Gerber et al, 2012). Many of these motivations can be attained without engaging in high-risk sports. If the appealing aspect of an activity is simply the connection with nature, this can be accomplished by other less risky means (e.g. rambling). Likewise, any sporting activity regardless of risk will lead to increased physical activity. The motivations regarding meeting a challenge, experiencing psychological resilience along with intense emotions, lend support to the sense of freedom outlined previously. Engagement within sports whereby a risk of severe injury

is possible upon failure (Zuckerman, 1994) accommodates all of the above as a means of positive behaviour. The sports chosen within this thesis will reflect this aspect of high-risk (skateboarding, snowboarding, BMX, etc) whilst exploring skill acquisition from the empirical study of implicit learning strategies concerning psychological resilience under intense emotions such as anxiety or fear. This aspect of implicit learning strategies with respect to physical risk within a sporting context is part of the original contribution to knowledge intended by this thesis.

High-risk sports such as skateboarding pose psychological demands on the athlete unlike no other (Way, 2012). In order to participate in these sports, athletes must maintain composure under serious levels of stress and anxiety due to the possibility of severe harm if the athlete fails (Cole, 2012). Research has shown that this can lead to a significant cognitive overload impairing physical performance (Orrell et al, 2009; Wong et al, 2008; Masters et al, 2007). This is attributed to an excessive internal focus on the production of one's actions, known as reinvestment (Masters, 1992). Reinvestment is understood to interfere with explicitly acquired information, given that explicit learning is subject to conscious control and elaboration. Learning can also be accomplished via other strategies (analogy, reduced feedback, guided discovery) to acquire knowledge implicitly in an attempt to limit the effects of reinvestment.

Research has shown significant advantages in acquiring implicit knowledge over a more explicit option whilst under stress. Implicit learning has been shown to be robust under conditions of psychological stress, (Gucciardi & Dimmock, 2008), temporal constraint (Masters et al, 2008a) and physiological

fatigue (Masters et al, 2008b; Poolton et al, 2007a). Reinvestment and implicit-based learning have yet to be examined within the field of high-risk sports. The current thesis will provide initial insight by investigating the potential benefits of applying a sample of these techniques.

Research within high-risk sports has identified the importance of digital technologies within the sporting culture between both coaches and students (Ellmer et al, 2019; Enright & Gard, 2016; Ma & Munter, 2014; Adi et al, 2010; Boyce & Bischak, 2010). Evidence supports the use of both video (Ellmer & Rynne, 2019; Enright & Gard, 2016; Boyce & Bischak, 2010; Booth & Thorpe, 2007) and live modelling from a peer (Enright & Gard, 2016; Boyce & Bischak, 2010) as effective means of feedback delivery to improve performance. Little evidence exists however, regarding the relative effectiveness of either by direct comparison via randomised controlled trials, or specifically within skill acquisition of complex whole-body movements. This thesis will provide further original contribution to knowledge by directly comparing these two modes of delivery in conjunction with implicit learning strategies of a complex whole body movement.

Over the course of this thesis, selected aspects of skill acquisition within high-risk sports will be explored aspiring to the following aims:

1. Explore the effect of participation in high-risk sports on the ability to endure high levels of arousal during the learning process and the impact it causes on performance under stress
2. Contrast and compare potential differences in the psychological trait known as sensation seeking between modern day high-risk sports and traditional

sports of similar movement classification (individual, self-paced, closed, non-contact).

3. Examine the effect of reinvestment and various practice-based learning strategies (analogy, guided discovery, explicit) in high-risk sports regarding conscious control of action. The use of implicit/explicit measures has yet to be tested within a physically high-risk environment and will provide substantial support for both the high-risk sports industry, and ongoing scientific study of conscious control amidst anxiety and arousal.
4. Provide initial insight into the application of such learning strategies (i.e. analogy, guided discovery, explicit) using a complex whole-body movement. Research to date (de Melker Worms et al, 2017; van Ginneken et al, 2017; Kinrade et al, 2010; Lam et al, 2009; Gucciardi & Dimmock, 2008) has relied on simple movement patterns with fine motor control utilising minimal coordination (e.g. card sorting, modified basketball free throw, table tennis serve, golf putting, darts). By examining this effectiveness with a complex, highly coordinated, whole body movement, this will provide the research field with greater ecological validity and practicability.
5. Provide further insight into the ongoing debate between live versus video instructional modelling. To date, minimal research has examined the two modes of instruction in direct comparison within the same study. Experimental validity can be sustained by directly comparing both forms of modelling using the same task and sample in a sporting context. Given the



current coaching opportunities both within and beyond the high-risk sports industry, any differences or equality in effectiveness will greatly benefit the coaching implications.

6. Investigate potential differences and subsequent effects of these learning strategies (i.e. Analogy, Explicit, Guided Discovery) at various stages of the learning spectrum from novice to professional. The majority of the research conducted to date has focused on the initial novice stage, whereby tasks and subsequent risk can be lower.
7. Provide initial insight into the effect of physical risk as a stressor. Physical risk has yet to be examined regarding conscious control and the manipulation of reinvestment in a sporting context. Risk (physical harm) increases both between high and low-risk classified sports (e.g. snowboarding and golf) along with complexity and performance (Zuckerman, 2014). This increase in risk can inherently influence reinvestment, at the various stages of learning and performance. Examining any variance in effectiveness of learning strategy at each stage of learning will highlight any need to alter the approach to learning, regarding conscious control.

As mentioned earlier in this chapter, the extreme sports community is at its highest peak in popularity to date (Snyder, 2018). Combining the expanding popularity, culture and education of these high-risk sports with the athlete's unique psychological aspects proposed by these attributes (novelty, boredom susceptibility, behavioural control, manipulation of emotion and attention), with

traditional learning literature may lack ecological validity. To date, minimal research has examined the effectiveness of both learning and education strategies on high-risk sports, juxtaposed to ample evidence of emotions such as fear and anxiety significantly impacting the cognition of athletes. The next chapter will examine research regarding skill acquisition in sport, with the current theoretical explanations and interventions associated with heightened emotion.

# Chapter 2

## Literature Review

### **2.1. Anxiety and successful performance**

The current thesis aims to explore skill acquisition when subjected to the stress created by engaging in high-risk sports. As mentioned previously, high-risk sports (skateboarding, downhill mountain biking, motor sport racing, etc.) are unique as participation involves accepting the actuality of physical harm whilst enduring any resulting anxiety. Anxiety during cognition and performance is a widely researched area, to date two theories lie at its epicentre; processing efficiency theory (Eysenck & Calvo, 1992) and attentional control theory (ACT) (Eysenck et al, 2007).

Rachman (2004) defined anxiety as tense, unsettling anticipation of a potential and threatening event resulting in a feeling of uneasy suspense. It is a negative affective state, whereby perception, attention, reasoning and memory must remain vigilant since all four processes interact (Rachman, 2004). These components are reminiscent of the four proposed mechanisms by Goldstone (1998) that are vital to effective facilitation of knowledge acquisition. These components are central in cognition and by allowing their interaction to remain robust when subjected to this 'negative affective state' an athlete can be provided with an invaluable foundation for effective performance.

Anxiety can be categorised between trait anxiety and state anxiety (Spielberger et al, 1970). Trait anxiety is related to a personality component

that predisposes individuals who are high in trait anxiety to respond anxiously to a given situation. People considered low in trait anxiety perceive and react to the world as less anxious (Rachman, 2004).

State anxiety, however, is different in many ways. It is dependent on the situation and the reaction of the individual to specifically perceived threat. It is defined as a reaction to a threatening event or stimuli, generating tension, apprehension and an increased physiological response, (Spielberger et al, 1970). This form of anxiety may only be present for limited periods and can dissipate once the threatening event passes (Rachman, 2004). State anxiety is categorised as the current level of anxiety specifically during a certain situation, dependent on the relationship between trait anxiety of the individual and situational specific stressors (Eysenck, 1992). A relationship is still evident despite the differences of these two factors in their origins. The occurrence and intensity of anxiety experienced from a given situation (state anxiety) is understandably influenced by the individuals predisposed susceptibility to anxiety in general (trait anxiety) (de la Mora et al, 2018). Along with this interaction both forms of anxiety have also been shown to disrupt complex cognitive tasks (see Eysenck, 1992).

Research has extensively examined the effects of anxiety on cognitive performance, whereby findings have shown high levels of anxiety (indiscriminate of origin) have impaired cognitive function and thus, dependant performance (Berggren & Derakshan, 2012; Eysenck & Derakshan, 2011; Ansari & Derakshan, 2011a, 2011b, 2010; Derakshan & Eysenck, 2009; Derakshan et al, 2009; Johnson & Gronlund, 2009; Ansari et al, 2008; Ashcraft & Kirk, 2001; Williams et al, 1997). Although this research shows that anxiety

affects cognitive performance specifically, the learning aspect of skill acquisition and motor production is a cognitive skill. Therefore, it is important to understand that anxiety will also impact skill acquisition and motor production (explored within the Implicit/Explicit learning strategies section of this literature review).

### 2.1.1. Early theoretical explanations of the effects of anxiety on cognition

Cognition is believed to be a complex process to understand and make meaning of the environment, by reflecting the individual's thoughts, beliefs, and modes of thinking and problem solving (Wilt et al, 2011). The way emotion negatively impacts cognitive performance has been of key importance in the development of cognitive psychology. Many theories have attempted to understand and account for this phenomenon (Eysenck et al, 2007; Eysenck & Calvo, 1992; Humphreys & Revelle, 1984). These theories have evolved throughout the context of cognitive psychology to specifically highlight and refine cognitive processes affected by emotion. Humphries & Revelle (1984) theorised that attention is interfered by worry due to task avoidance motivation, causing fewer resources to be allocated to the required task and impairing performance. Sarason (1988, 1984), attributed similar negative effects of anxiety in terms of worrisome thoughts that inherently reduce attention and affect cognitive performance.

The above theories were developed on limited knowledge of working memory and supporting research. Although these theories offer an explanation for the effects of anxiety, they remain vague as to the specific impact that anxiety can have upon the specific contents of working memory. The processing efficiency

theory (Eysenck & Calvo, 1992) identifies the central executive as the affected component of working memory but fails to expand on which of the functions of the central executive are specifically impaired. Research following this provided greater insight into the components of working memory, allowing for more specificity in developing Attention Control Theory (ACT) (Eysenck et al, 2007).

Processing Efficiency Theory (Eysenck and Calvo, 1992) considers 'effectiveness' to refer to the quality of the task performance, whilst 'efficiency' is concerned by what degree of effort is required to sustain success (Eysenck et al, 2007). The efficiency of the movement will decrease, as more attentional resources are required to uphold performance, as more processing is required by the central executive under the greater attentional demand. Anxiety is understood to have a lesser impact on task effectiveness as anxious individuals utilise more processing resources to reduce the negative effect of anxiety on performance (see Eysenck et al, 2007 for a review). This however fails to explain how skill acquisition (see Masters & Maxwell, 2008 for review) requiring high levels of cognition fail to be as effective during times of stress induced anxiety.

Attentional control theory (ACT), developed by Eysenck et al (2007), identified precise functions of the central executive within the working memory model (Baddeley, 2000). These functions are responsible for attentional control and are effectively impaired when cognition is subjected to anxiety. ACT suggests that anxiety affects both the capacity and ability to maintain effective attentional control, by redirecting attention both within and between tasks as required

(shifting function). Conversely, it also affects the ability to inhibit attention to irrelevant stimuli or responses (inhibition function). Although anxiety is understood to impact the performance efficiency of shifting and inhibition functions, the performance effectiveness is understood to be less impaired (Derakshan & Eysenck, 2009). This is justified using indirect measures and simpler cognitive skills. The target goal is still completed successfully, whilst task efficiency is justified as being impaired due to increased completion time. Research using more complex cognition, along with movement has shown that performance effectiveness can also be impaired as a result of emotions influencing rumination of performance (see reinvestment section of this literature review p.34).

The next section of this literature review will focus on presenting an overview of the relevant theories pertaining to arousal from arising anxiety and other emotions on performance. The focus will remain on attentional control theories, regarding the effect of anxiety on functions from multiple aspects of the working memory model (Baddeley 2000), particularly the central executive. Following that, the issue of motivation and anxiety will be examined and finally, the evidence supporting the notion of anxiety impairing performance efficiency over performance effectiveness will be reviewed.

### 2.1.2. Emotion and the effect of arousal on cognition

The following theories all contain perspective on how experiencing emotion impacts cognition. Although they differ in specificity and depiction of emotion, the fundamental constant throughout is the debilitating effect on the

ability to adhere to the attentional demands through heightened arousal from environmental stimuli. This concept is grounded through a possible cognitive deficit known as the “inverted U’ theory or Yerkes-Dodson law (Yerkes & Dodson, 1908). It suggests that all activities require an optimal level of arousal to perform most effectively. When arousal is less than optimal, attentional cues can be missed due to lack of attention. When arousal becomes heightened beyond the optimal level, cues are missed because of an overload to sensory systems. Task complexity has been discussed in relation to optimal level, suggesting that high arousal be suited for simpler tasks, whilst low arousal is best suited for more complex, or less practiced tasks (Baddeley, 1972; Broadbent, 1971).

Another approach to the study of anxiety-athletic performance is the development of catastrophe theory (Hardy & Fazey, 1987). The theory combines the joint effects of both somatic and cognitive subcomponents of anxiety, with the effect on performance. It predicts that cognitive anxiety directly influences performance as well as mediating the effects of somatic anxiety. Catastrophe theory further predicts that somatic anxiety will differentially influence performance depending on levels of cognitive anxiety experienced. Somatic anxiety is not necessarily detrimental to performance but is associated with catastrophic effects when coupled with high cognitive anxiety (Hardy & Fazey, 1987). When cognitive anxiety is low, somatic anxiety may have minor beneficial effects on performance (Krane, 1990). Hardy & Fazey (1987) also hypothesised that as somatic anxiety is increasing up toward one's optimal level, and cognitive anxiety is low, performance will be facilitated. However, when both cognitive and somatic anxiety are high beyond



the optimal point, performance will be severely impacted and plummet drastically. This is currently considered to be the most relevant theory accepted, advanced and evaluated which attempts to define the relationship of anxiety on performance (Ingugiro, 1999). This is based on its inclusion of multifaceted aspects of anxiety along with a more realistic approach towards anxiety and performance against the smooth curvilinear approach by the theories before it.

When the athlete has experienced a catastrophic event, drastic changes in cognitive and somatic anxiety levels are required for performance to return to a moderate level. This theory has been examined, reducing the cognitive load and therefore demand on attentional systems via a refocus of attention. It can allow the athlete to utilise other forms of anxiety for the benefits of optimal arousal under both physically (Dali & Parnabas, 2018) and cognitively (Vitasari et al, 2011) demanding tasks.

Baddeley & Flemming (1967) conducted research on deep sea diving and found that secondary task load did not affect performance when diving at depth (increased danger and complexity). Lavie (2000; 1995) reasoned that this contradictory finding may be due to a dissociative effect. The capacity of irrelevant or peripheral stimuli may decrease as task complexity becomes greater. The increase in complexity could force a perceptual narrowing of focus, creating a dissociative effect and distracting you from the danger of the task involved. Therefore, as the performer dives to greater depth, the focus of attention becomes more refined, consequently inhibiting irrelevant stimuli.

Research suggests that high arousal (e.g. fear induced anxiety) can cause a narrowing in the field of attention (Baddeley, 2007). Research conducted on deep-sea divers supported the attentional narrowing hypothesis. Although central task management was maintained, the peripheral attention was debilitated when placed under higher levels of stress derived from environments of increasingly greater danger (Baddeley, 1996; Weltman et al, 1971; 1970). This is in support of the Resource Allocation model (Ellis & Moore, 1999; Ellis & Ashbrook, 1988) proposing that stimuli utilising the attentional capacity, are likely to exacerbate the effects of emotion (Baddeley, 2007). Williams et al (1997) found that extreme emotion can cause a tendency of patients to bias their attention towards the stimulus, either directly or indirectly responsible for inducing fear. This is known as the attentional bias theory and is understood to operate in a range of modalities including visual, auditory or tactile. The bias is primarily involuntary in nature and is triggered by both external environmental cues or internally, as a result of past memories or intrusive thoughts (Baddeley, 2007). It is understood that this bias is based on the principle that performers direct their attention to the fearful stimuli as opposed to an inability to access their inhibitory process of impairment (Fox et al, 2001; Fox, 1994). Therefore, indicating that arousal induces a hyper activation of the positive attentional process (shifting) and not subduing the negative attentional process (inhibition).

Similarly, Eysenck (1992), also proposed that anxiety was associated with cognitive bias (attentional bias, interpretive bias, negative bias). Based on previous cognitive theory, Eysenck (2000; 1997) proposed the four-factor theory of trait anxiety. The theory states that the emotional experience of

anxiety is associated to four sources of stimuli. The first source is derived from external environmental cues, as the attention and interpretation of the situation specific stimuli. The remaining three sources are attended to from an internal perspective such as; physiological information (e.g. heart rate / breathing rate), possible outcomes for future situations stored within long term memory (worrisome thoughts) and thoughts regarding the individual's own behaviour during the current environment (self-awareness). According to this theory, the effect of anxiety is dependent on how these four informational sources are attended to and more importantly, interpreted. The major assumption of this theory is that anxiety induces a cognitive bias when external stimuli are interpreted as threatening, or by internal stimuli such as worries. This assumption is in agreement with the attentional bias theory (Williams et al, 1997). Attentional and interpretive biases are associated with anxiety and are determined by the interaction between trait anxiety (predisposed individual vulnerability to anxiety) and state anxiety (environmental stressors). The assumption of the four-factor theory has been empirically supported (see Eysenck, 2000 for a full review).

### 2.1.3. Anxiety and Threat

The existence of attentional bias is supported from a range of research areas from clinical eating disorders (Schotte et al, 1990), medical operations (Parkinson & Rachman, 1981) and a range of behavioural psychology studies (Mogg et al, 1990; MacLeod & Mathews, 1988; MacLeod et al, 1986; Mathews & MacLeod, 1986). Fear has been shown to be significantly effective in activating attentional bias using emotional stroop tests with varying social

phobias (Duval et al, 2018; Mogg, et al, 2004; Amir et al, 2009; 2003; Hope et al, 1990), arachnophobia (Gremsl et al, 2018; Watts et al, 1986) and surviving drug overdose patients (Williams & Broadent, 1986). Mathews & MacLeod (1985) successfully demonstrated attentional bias within stroop tests using the threat of pain and physical fear. This is supportive to the aim of the current thesis, as research into reinvestment has found similar findings in creating cognitive arousal as a result of avoiding physical threat (Orrell et al, 2009; Wong et al, 2008; Masters et al, 2007). One of the aims of this thesis is to explore the effect of participation in high-risk sports on the ability to endure high levels of arousal during the learning process and the impact it has on performance under stress.

Attentional bias towards threat is considered most simply as a pure survivalist strategy as proposed by Beck & Clark's cognitive model. Beck & Clark (1997) suggested anxiety is directed by biases through three interactive processes. Firstly, at the initial registration of a threat stimuli, that consequently enables what is referred to as a 'primal threat mode'. This results in a secondary activation of more elaborative and reflective thought processes. The first mode is primarily instinctive with automatic orientation to threat and is stimulus driven. The primal mode is dependent on recognition of personally relevant, negatively perceived stimuli. This mode then leads to the activation of a combination of cognitive, affective, behavioural and often psycho-physiological responses. Beck & Clark's model regards these responses as innate, and predominantly inflexible, as they are developed to inherently maximise survival. It is this stage that is responsible for orienting attention towards threat along with any reactions involved with coping with said threat.

The final stage of the model shows the process of secondary elaboration, whereby schema driven processing of threat takes place, and is inherently slow and effortful in design.

As previously mentioned, Williams et al (1988) proposed the notion of a precocious detection system, followed by an evaluation system. They assumed that incoming stimuli is reviewed based on degree of threat by an 'affective decision mechanism' (ADM). Upon successful appraisal of highly threatening stimuli, a 'resource allocation mechanism' (RAM) is activated. This RAM system is designed to augment the attentional bias or inhibition process (Williams, et al 1997). Attention is then either maintained to the task at hand when threat is low or concentrated toward stimuli when appraised as high. Those high in trait anxiety will focus on the potential threat, whilst those low in this trait will ignore the threat through inhibition (Williams et al, 1988). This idea has been criticised from an evolutionary perspective. The blank assumption that an individual will consistently continue to ignore a threat regardless of size and severity has been considered implausible based on an oversimplified context (Matthews & Mackintosh, 1998; Mogg & Bradley, 1998).

In order to resolve these criticisms, Matthews & Mackintosh (1998) and Mogg & Bradley (1998) developed corresponding models. Mogg & Bradley (1998) expanded on the cognitive-motivational hypothesis by Williams et al (1988). The main assumption of this hypothesis is that stimuli can have both a valence (positive or negative) and a motivational component. Anxiety will be motivationally aversive, resulting in a heightened level of attention, and a rapid response to threat with increased autonomic activation (Baddeley, 2007).

Similarly to Williams et al, the model proposed by Mogg & Bradley (1998) consists of two stages, where one stage is designed to detect and evaluate the potential threat of the stimuli. The second stage is concerned with developing and implementation of the subsequent cognitive processing needed to continue. However, the updated model (Mogg & Bradley, 2005) interprets the influence of anxiety (be it state, or trait induced) as operating through a bias in the evaluative process within the first stage. Anxiety will result in the subject having a lower threshold beyond which a potential threat can attract attention. Furthermore, they assumed that slightly negative stimuli will cause a tendency to inhibit attention that should be actively ignored (Baddeley, 2007). They suggested that the paradoxical tendency for low levels of threat to lead to inhibition has two possible benefits. Firstly, to aid the focus of attention, by reducing sensitivity to mildly negative stimuli. Secondly, to force attention to be positively biased and thereby reducing the tendency of negative feelings to impair activity, providing an evolutionary advantage (Baddeley, 2007).

This relates to the current thesis as successful performance minimises the risk and is ascertained by focussing attention towards the mechanics of the movement in order to succeed. Any attentional focus derived from negative stimuli as fear of injury/failure will be transitioned into positive stimuli as a means of 'survival by success'. The term 'survival by success' is being proposed by the current thesis as an original concept by providing initial insight into the concept of physical harm as an anxiety inducing stressor, which is yet to be addressed in relation to skill acquisition literature.

Another model that shares many assumptions in line with the cognitive motivation model (Mogg & Bradley, 1998) is developed by Mathews,

Mackintosh and Fulcher (1997) and Matthews & Mackintosh (1998). This model is in agreement with Williams et al (1997) whereby attentional bias is only created when threat is in direct competition with other stimuli/task demands. This model proposes a threat evaluation system (TES) characteristically similar to the ADM of Williams et al (1997) model. Automatic evaluation of stimulus input is fed into a distraction/threat representation system. The interference caused by this process is accumulated and measured against the voluntary effort aimed at attending to the threat, in order to strengthen those representations. It is hypothesised that the output of the TES is facilitated by anxiety level. This requires stimulus input to exceed a specific threshold before output can be directed from the TES into the distraction representation. Heightened anxiety is believed to lower the TES threshold value, resulting in an increased output of the system. In contrast with Williams et al (1988), this model proposes that strong danger cues will attract attention in everyone, whereas weak danger cues will only be identified by those with heightened anxiety levels. This can relate to high-risk sports as many of the detection systems such as the affective detection mechanism (Williams et al, 1997;1988) or the threat evaluation system (Matthews & Mackintosh, 1998) will prioritise the physical risk involved in failing such sports. Past memories or even common sense can emphasise that the risk of injury (potentially severe) to the athlete is high and is often what draws attention to its appeal (Dyrdek, 2012). These detection systems are devised to identify such risk and prioritise attentional resources.

Regarding the current thesis, the concept of evaluating an attentional threshold-based threat is highly applicable. Performing within high-risk sports induces fear (negative arousal) based on risk of physical threat (Buckley, 2016;

2015). This fear can then consequently impact the goal engagement system and subsequent attentional processes. Under high threat, the attention is oriented towards the threat, however during mid-levels of threat the attention can be directed towards positive stimuli by prioritisation. Successful performance and therefore execution of the motor skill allows the performer to remain safe and can therefore be seen as positive stimuli. By viewing the parameters of the movement as positive stimuli by the valence evaluation system, this could cause a bias in attention due to positive prioritisation. This is in accordance with the goal engagement system of the cognitive-motivation hypothesis model proposed by Mogg & Bradley (2005).

#### 2.1.4. Attention and positive emotion

The literature reviewed up to now has focussed on the impact of negative emotions, and their effect on attention. The majority of literature associated with this, explores the impact of negative emotions such as anxiety as a symptom or even the cause of such emotions from worrisome thoughts. There is a body of research that has viewed the opposing end of the emotional spectrum, known as desire. Desire has been explored from a craving/addiction perspective, whereby a positive emotion impacts our attention towards a stimulus the individual desire/crave. Several studies have observed that stimuli associated with addiction/craving, can create an equally effective attentional bias as fear. These findings are from a variety of addictive/desirable stimuli from simple pleasures such as food (Andrade et al, 2016; Green et al, 1997; Green & Rogers, 1995), substance abuse (Sayette, 2016; Mogg et al, 2003) and even psychological behaviours such as gambling (Cornil et al, 2018).



Addictive personality behaviour has been linked with the personality trait 'sensation seeking' (see Zuckerman, 2007 for a review). This personality trait has also been associated with individuals who engage in high-risk sports as discussed in the previous chapter.

Buckley (2015) examined adventure activities regarding them as activities whereby participation involved exposure to high levels of physical risk. The study argued that participants within these sports experience powerful behavioural addictions, leading them to carry out their preferred activities at ever increasing levels of physical risk. One of the confirming criteria for Buckley's (2015) findings was the impact of mood modification and emotional reward that was experienced from performing within these high-risk sports. During the adventure activities practitioners experience emotions of thrill and excitement (Buckley, 2014; Houge Mackenzie & Kerr, 2013; Holyfield, 1999). Buckley (2016) highlighted a relationship between thrill and fear whereby the two can exist within varying levels of one another whilst yielding an increased concentration of prioritised stimuli. As one aspect of adventure sports are characterised by a high physical risk and also addictive behaviour to increase this physical risk (Buckley, 2015), it is also feasible to believe that this enhanced concentration of focus will continue to occur.

The elaboration intrusion theory (EIT) of craving (Kavanagh et al, 2005) was developed to account for this attentional bias towards desired stimuli. The theory is based on the assumption that desires, be it cravings (food, drugs etc) or emotional dependence (empathy of a loved one, or thrill of excitement) can result in appetitive targets automatically triggering intrusive thoughts. This can occur through either physiological cues (hunger pangs), external cues (smell

of food), or by cognitive association, such as the rattle of plates. This can correspond to high-risk sport such as snowboarding, whereby hormonal responses invoke a physiological cue. An external cue could be the sound of snow compressing, or a cognitive association between the memory of major injury and the current trick being attempted. The EIT is assumed to have two effects, one automatic and associated with pleasure, whilst the second is cognitively mediated causing elaboration on the cue. These elaborations are believed to interfere with the operation of working memory by displacing more constructive thoughts. This is similar to the disruptive interference caused by worry in previous theories (PET & ACT). The elaboration highlights the characteristics of the target, leading to temporary emotional rewards. This then amplifies the awareness of the somatic/emotional deficit that remains afterwards, leading to longer term frustration.

Craving has been regarded as the mirror image of anxiety, one biasing attention towards a source of threat and the other resulting in excessive attention to stimuli that evoke the object of desire (Baddeley, 2007). It is plausible for individuals who engage in high-risk sports to view the element of risk or danger, as appealing and focus attention toward it. Way (2012) identified “pushing beyond your limits, in the face of risk and danger is what makes skateboarding better than other (traditional lower risk) sports”. The greater the risk, the greater the potential attentional bias to be created. By elaborating on the risk of performance, it could reinforce further attentional bias if the risk becomes greater because of worry from a greater potential for injury.

Both the elaboration intrusion theory (Kavanagh et al. 2005) and cognitive motivational hypothesis (Mogg & Bradley, 1998) consider emotion, be it negative or positive to be responsible for creating an attentional bias. The

current thesis aims to explore the potential effect if the element of risk, whilst worrisome in nature, could also be elaborated upon positively. If stimuli can be interpreted from both perspectives, the attentional bias created could have significant influence on any cognition that is governed by attention.

#### 2.1.5. Anxiety and minimal control

The research discussed up to this point, has focussed on the bias towards threat being automatic, uncontrollable, and unconscious in design. There is a selection of models that differ, by acknowledging the existence of some conscious control of attention.

Firstly, the guided threat evaluation model proposed by Bar-Haim et al (2007), suggests that attentional bias is initiated through sequential disfunction in a temporal chain of subsystems. An initial pre attentive threat evaluation system (alike to the TES threshold proposed by Matthews & Mackintosh, 1998) evaluates environmental stimuli directing threatening stimuli into a resource allocation system. If the threat level is evaluated as low by the pre attentive system then the focus is shifted back towards the goal directed stimuli. When a threat is considered high, attention is maintained and the system elicits physiological arousal and subsequent available cognitive capital onto the cue. A guided threat evaluation system proceeds to then review the threatening context and assess available coping strategies on a conscious level. One such coping strategy could be to rely on previous knowledge/experience in order to avoid previous mistakes.

Memory recall during attentional bias is shared partially by the feature detection model (Ohman, 1996; 2005). The work on attentional bias to threat is generally focussed as an evolutionary adaptive process, using primarily unconscious processing. Stimuli are inputted and analysed by the 'feature detection system' whereby biologically prepared or intense stimuli exert direct influence on the arousal system. This generated arousal facilitates attention towards threat without any conscious mediation similar to other models mentioned earlier. When information passes beyond the feature detection system, it is believed to enter a 'significance evaluation system'. This system is governed by conscious perception and requires slow conscious appraisal of threatening stimuli to ascertain meaning. Meaning is only understood however, through the interaction of emotional memories stored within a third subsystem known as the 'expectancy system'. Previously encountered experiences and memories are used as a feedback loop in the model between the arousal system and significance evaluation system as a means of regulating one another. This regulation can cause heightened arousal to sensitise the significance evaluations at that point or cause specific stimuli to be predisposed as sensitive within the expectancy system based on prior learning from previous experiences.

Previous experiences or memories were also seen to be at the root of attentional bias by Wells & Matthews (1994). This model views attentional bias as a computational accident. The model adopted a top down process approach known as the 'self-regulatory executive function' model. It proposes that attentional bias is related to self-knowledge using voluntary task goals or demands to both guide and moderate attention. It is hypothesised by the model

that anxiety is formed through a consciously perceived threat to self-perseverance and motivates the individual to monitor the threat. Wells & Matthews argued that attentional biases are created simply because the individuals believe it is important to focus/monitor threat. This notion fails to explain how an unconscious attentional bias can be evident, however Matthews & Wells (2000) speculated that attentional bias can be maintained without awareness due to voluntary strategies.

With relation to the current thesis, individuals engaging in high-risk sports could view the potential risk of physical harm as threatening. Regarding the mechanisms that mediate attentional bias towards threat, the models discussed so far differ on the specific way an individual attends to threat; they all posit some form of threat detection system (Bar-Haim et al, 2007; Eysenck et al 2007; Matthews & Mackintosh, 1998; Mogg & Bradley, 1998; Beck & Clark, 1997; Ohman et al, 1996). Only one model (Wells & Matthews, 1994) suggests that the bias is not created through an automatic threat detection system but by choice.

Modulation of attentional bias will be discussed comparing the theoretical contrasts as to how the threat is identified between the remaining models. A resource allocation mechanism for cognitive resources is proposed by some of the models (Bar-Haim et al, 2007; Mogg & Bradley, 1998; Williams et al 1988). Some postulate a threat elaboration mechanism, by which strategic evaluation identifies threat based on severity (Bar-Haim et al, 2007; Beck & Clark, 1997). Others pose some form of strategic goal engagement mechanic where the performer's goals, beliefs or voluntary drive can modulate or possibly override attention to threatening stimuli (Bar-Haim et al, 2007; Eysenck et al 2007; Matthews & Mackintosh, 1998; Wells & Matthews, 1994). This motivational

drive may be linked to some cultural belief held by those participating in high-risk sports, within the sporting community discussed earlier in the introduction. Regardless of these differences, all of the models attribute a single common trait that elicits a form of arousal, usually within the form of anxiety/worry. These models mentioned so far attempt to explain the mechanisms behind why attentional bias is created, whereas few have explored what effect this attentional bias can have on cognition and the learning process dependant on it.

A pivotal theory concerning the relationship between attention and cognition is the attentional control theory (ACT), developed by Eysenck et al (2007). It is a development and improvement on the original theory it was founded on, known as the processing efficiency theory (PET) (Eysenck & Calvo, 1992). The processing efficiency theory was developed to account for the effects of anxiety on cognitive performance focussing on three main assumptions. The first is the distinction between performance effectiveness and performance efficiency. Performance effectiveness being related to quality/result of performance, using response accuracy as the main form of measurement. Performance efficiency is concerned with the relation between effort and resources needed to achieve successful performance. Response time is primarily used as an indirect measure of performance efficiency. According to PET, highly anxious individuals are more affected regarding performance efficiency, rather than effectiveness. This is attributed to worrisome thoughts allowing anxiety to interfere with performance as they drain the limited attentional resources available in the central executive, thus leaving fewer resources available for efficient processing.

Worries are defined as a chain of thoughts, concerned with expectations for possible negative outcomes, usually failure or evaluation (Borkovec et al, 1983). Worries are a crucial component of anxiety, generally activated within stressful situations, and generally reported more within high trait anxious individuals (Borkovec et al, 1983). This is attributed to a higher propensity to both experience and interpret certain situations as more stressful than low-anxious individuals (Eysenck, 1992). The overall experience of worry causes increased effort by the individual to use extra resources to be more motivated and succeed. This use of extra resources leads to impairment within the processing efficacy.

Worrisome thoughts are the central construct in the second main assumption of PET. This assumption states that worries are responsible for the effects of anxiety on performance (Eysenck & Calvo, 1992). Anxiety has been associated with worries as high-anxious individuals have reported more worries through self-preoccupation when compared with the low anxious individuals (Eysenck, 1992). Morris et al (1981) found that performance was affected by anxiety because of worrisome thoughts that were maintained and resulted from stressful situations.

The final assumption of the processing efficiency theory concerns the working memory. PET states that the central executive of the working memory is mainly affected by anxiety along with the phonological loop. The central executive is responsible for controlling the other components of working memory and has attentional control as its primary function (Baddeley, 2007).

There is support from research for these assumptions as Ashcraft & Kirk (2001) and Eysenck & Derakshan (2011) both found processing efficiency to be greatly affected during varying levels of complexity within a letter-transformation task between high and low-anxious individuals. Not only did highly anxious individuals show higher reaction times when compared to low-anxious counterparts, but that tasks dependant on working memory were adversely affected as the demands on working memory increased. The research concluded that as tasks become more demanding on the central executive, processing efficiency is affected.

Eysenck et al (2007) has criticised PET, suggesting two main limitations. Firstly, it is too vague regarding the effects of anxiety on the central executive. Although the theory highlights the central executive as the target effect, it fails to identify the specific central executive functions that are impacted and impaired by anxiety. Secondly, it fails to account for why high-anxious individuals become more distracted by task irrelevant stimuli (Hopko et al, 1998; Calvo & Eysenck, 1996). Based upon these criticisms Eysenck et al, (2007) developed an updated theory regarding anxiety and cognitive performance, known as the Attentional Control Theory.

#### 2.1.6. Attentional Control Theory (ACT)

The main assumption of Attentional Control Theory (Eysenck et al, 2007) is that attentional control is impaired by arousal created by anxiety. Attentional control has been said to be either driven by a stimuli orientation (bottom up approach) or goal orientated top down approach, but there is always a balanced interaction between these two systems (Yantis, 1998). ACT



suggests that this balance is disrupted by anxiety, affecting the central executive functions involved in attentional control. The functions most impaired by anxiety in question are the inhibition and shifting functions of the central executive. The shifting function is known as the capacity to redirect attention both between and within the task demands, whilst the inhibition function is the extent of the ability to disallow distracting or prepotent responses (Derakshan & Eysenck, 2009; Eysenck et al, 2007; Miyake et al, 2000). This is a main improvement of the ACT developing beyond the processing efficiency theory (Eysenck & Calvo, 1992) because it addresses the affected root and mechanisms of disruption.

Literature has found a negative effect of high anxiety on the shifting function of the central executive resulting in an impaired ability to operate (Pacheo-Unguetti et al, 2010; Johnson, 2009; Derakshan et al, 2009b; Reinholdt-Dunne et al, 2009; Ansari et al, 2008; Bar-Haim et al, 2007). ACT accounts for such results suggesting anxiety reduces attentional control causing it to become driven by stimuli over current goals, reducing the capacity to actively switch attention (Eysenck et al, 2007; Derakshan & Eysenck, 2009). This concept is echoed in the resource sharing hypothesis (Baddeley, 2007). Results have been consistent in a selection of tasks ranging from mental calculations (Derakshan et al, 2009) to saccadic eye movements (Ansari et al, 2008) and facial recognition paradigms using emotionally augmented stimuli (Johnson, 2009; Rinck & Becker, 2005). Although the research provides a clearer understanding of the theoretical concept involved within the central executive, it lacks the ecological validity of application to a sporting context. Wilson et al (2009a; 2009b) found anxiety impaired performance as a result of

anxiety directing attention in accordance with ACT as stimulus driven attention control became dominant over resources for goal directed behaviour. Similar principles have been discovered within visual search strategy throughout research in a sporting context (see Williams et al, 1999 for a review). The research reviewed supports the adoption of more implicit-based acquisition of knowledge as a means of alleviating the stress that is imposed on working memory. Implicit-based learning research and the variety of techniques employed within sport are reviewed later in this chapter.

According to ACT, the inhibition function of the central executive attempts to protect cognition by ignoring distractors or prepotent, dominant or otherwise automatic responses (Miyake et al, 2000; Friedman & Miyake, 2004). Inhibition as a process has been presented through research in several ways. Nigg (2000) identified four individual forms of inhibition; interference control (caused by competition between stimuli), cognitive inhibition (nullify irrelevant stimuli from working memory), behavioural inhibition (suppression of automatic responses) and oculomotor inhibition (suppress reflex saccades). These are similar to the inhibitor processes put forward by Friedman & Miyake (2004); proactive interference resistance (resistance to irrelevant memory intrusions), prepotent response inhibition (withstand automatic behavioural responses) and distractor interference resistance (resist task irrelevant stimuli). The two interpretations view inhibition similarly by the notion of nullifying distracting external irrelevant stimuli or behaviour. Friedman & Miyake (2004) have included the possibility of resistance against memory-based intrusion. This is particularly relevant to the current thesis as previous memories could be a significant distractor in high-risk sporting environments given the potential

effects described by the models mentioned previously. Proactive interference was found not be associated with the other two inhibition functions. The distractor resistance and prepotent response inhibition were found to be associated suggesting shared common processes (Friedman & Miyake, 2004). ACT considers anxiety to impact the inhibition function in the same way it impairs the shifting function. Attentional control is impaired by anxiety because of the shift from a goal driven control to stimuli driven control. This increases the probability that processing resources will be diverted towards task irrelevant stimuli, and in turn debilitate the efficiency of the inhibition function (Eysenck et al, 2007).

There is a large collection of research showing that the inhibition function is severely hindered when exposed to threatening stimuli (see Cisler & Koster, 2010; Eysenck et al, 2007 for a review). High levels of anxiety cause an individual to become more distracted by task irreverent stimuli considered to be threatening (Eysenck et al, 2007). Some research has used emotionally threatening stimuli to successfully convey anxiety. The research showed that attentional control was greatly affected by the processing of emotional stimuli (Derakshan et al, 2011; Reinholdt-Dunne et al, 2009; Derakshan et al, 2009b; Garner et al, 2009; Wieser et al, 2009; Miyake et al, 2000). The results concur with Eysenck et al (2007) whereby anxious individuals will have greater difficulty inhibiting prepotent responses. This inhibitory effect has been supported by current research (Ansari & Derakshan, 2011a; Bishop, 2009) and using fMRI. The findings suggest that high anxious individuals used a greater amount of attentional resources (by a greater activation of the left dorsal prefrontal cortex, [DLPFC]) suggesting a decrease of inhibitory repossess. Overall, research has consistently found that anxiety can be significantly

influential by impairing attentional control through inefficient inhibitory functions. This is caused by a direct impact from distracting stimuli when considered threatening (Eysenck et al, 2007).

So far, this review has focussed on potential explanations of what can occur when perception, cognition and threat are combined, and their influence on working memory. The question as to how this bias can transition into movements (more importantly, sporting performance) is yet to be addressed. Many of the approaches discussed, argue that attentional bias is caused due to the presentation and identification of threat. Upon occurrence it is natural to seek out a potential solution to this threat or stress, be it either confronting the threat or evading it (Plaford, 2013). The common aspect of either 'fight or flight' responses are to maintain safety and minimise the threat. In high-risk sports, the threatening aspect of any performance is considered a motivating factor and achievement when confronting that threat (Way, 2012). The best chance for survival is to perform successfully (Rodriguez, 2017; Way, 2012), therefore placing considerable attention on the execution the skill. The current thesis hypothesises that this attention bias can be created as a result of physical threat, subsequently guiding the attention towards the mechanics of skills to ensure survival. This internal focus of attention toward the performers and movements has been identified as 'reinvestment' (Masters, 1992). The next section of this chapter will review the concept known as reinvestment, whereby attentional bias and threat can impact on movement execution as a result of impaired cognition.

## **2.2. Reinvesting in the individuals' responses**

### **2.2.1. Attention and Self-focus**

Attention is crucial to observational learning and the means to deliver such information, be it implicit or explicit in nature. Learning via observation (external stimuli) will be discussed later in the chapter along with the varying approaches towards delivery concerning knowledge acquisition (internal stimuli) through implicit/explicit means.

By effectively manipulating attention, skill acquisition can be facilitated. There is a wealth of research conducted within multiple sporting environments demonstrating a significant preference to an external focus of attention, (van Ginneken et al, 2017; Wulf et al, 2007; Perkins-Ceccato et al, 2003; Wulf et al, 2003; Wulf et al, 2001; Wulf et al, 2000). Performance has also been shown to become significantly debilitated through adoption of an internal focus, (Coombes et al, 2009; Jackson et al, 2006; Ford et al, 2005; Gray 2004; Beilock et al, 2002). This is attributed to the constraining effect, inhibiting the automatic control mechanisms of motor control explained through a multitude of hypotheses (Masters & Maxwell, 2008). When teaching a novel skill, attention is required to be predominantly internally directed to ensure that the skill is adequately focussed on. This is often performed through self-focus. When this occurs, the mind attempts to control the actions and emotions of the movement associated with the perceived goals of the task through self-regulation, (Carver & Scheiver, 1998; Duval & Wicklund, 1972).

Self-regulation varies in definition depending on context. From a social cognitive approach, it refers to a cyclical process that involves self-generated thoughts, feelings, and actions that are systematically directed towards

achieving personal goals (Zimmerman, 1989). This cycle can promote self-evaluation, resulting in the systematic comparison of their own movements, and the performance of the observed behavioural goal, (Duval & Wicklund, 1972). Failure to match successfully, promotes effort towards discrepancy reduction (Carver & Scheiver, 1998), where the learner enters a behavioural cycle until a successful match is achieved, (Panayiotou & Vrana, 2004). A variety of behaviours involves directing attention internally towards varying facets of the 'self', (Mor & Winquist, 2002). A specific form of self-focus transpires when the task-orientated movements of the skill become consciously attended to. Research by Kal et al (2018a; 2018b; 2013) has found that a preference for internally directed focus of attention and a phenomenon known as reinvestment are positively linked. Masters (1993) developed the term 'reinvestment' to account for this unique form of self-focus. This is a concept whereby automatised motor skill becomes undone via 'reinvesting actions and percept's with attention' (Deikman, 1969).

### 2.2.1. Reinvestment and declarative knowledge

The term 'Reinvestment' is defined as the manipulation of conscious, explicit, rule-based knowledge and working memory, to control the mechanics of movement during skill execution, (Masters & Maxwell, 2004). The Reinvestment theory originally proposed by Masters (1992) suggests that reinvesting within movement can disrupt motor production through conscious control using declarative knowledge. This concept has been found to exist through an abundance of research connecting psychological pressure and conscious motor control, (Gucciardi & Dimmock, 2008; Wilson et al, 2007;

Mullen et al, 2007; Mullen, Hardy & Tattersall, 2005; Pijpers et al, 2005; Wan & Huon, 2005; Masters & Maxwell, 2004; Hardy, Mullen & Martin, 2001; Masters, Polman & Hammond, 1993). The research shows that performance is significantly hindered by consciously attending to the movement parameters whilst performing inside a pressurised, highly self-focussed environment. Declarative knowledge has been linked to working memory (Baddeley, 2007), and task-relevant declarative knowledge under conscious control. This is through a similar process to self-regulation, as the individual recalls past memories and initiates hypothesis testing as a result, (Poolton et al, 2005). According to Masters & Maxwell (2008), the association with reinvestment and declarative knowledge is highly influential. Koedijker et al (2007) concluded that the quantity of declarative knowledge is more of a leading factor than direction of attention alone with regard to conscious motor processing. This finding is in agreement with research conducted by Poolton et al (2004) when the propensity to reinvest information under pressure was greater as the degree of task-relevant knowledge increased. By limiting the accumulation of declarative knowledge, the possibility of reinvestment can be reduced allowing for more successful performance under pressure.

Skill acquisition has been researched across varying levels of skill. Beilock & Carr (2001) showed that when expert golfers performed under consciously demanding tasks (via equipment alterations & psychological pressure), they reported more explicitly detailed episodic knowledge of the parameters of the skill. Similar trends have been shown by Liao & Masters (2002) where self-focussed practice accumulated a large pool of declarative knowledge. This consciously available task-specific knowledge was also used as a negative predictor of performance under pressure.

Reinvestment has also been shown to increase with regards to providing an excessive information regarding incorrect focus. Gray et al (2017) examined the use of manipulating incorrect and correct only target zones within expert baseball pitching. Results showed that attracting or highlighting attention towards more information (i.e. incorrect target zones), performance declined under pressure. This was attributed due to an increase in reinvestment regarding their pitching techniques as to avoid incorrect technique and therefore incorrect target zones.

Reinvestment has been shown to be a possible personality trait, and individuals who reported a tendency to reinvest in their performance, known as 'high reinvesters', accumulated significantly more task-specific knowledge than 'low reinvesters' (Maxwell et al, 2000). Skill level has yet to be explored regarding reinvestment, as minimal research has yet to explore the reinvestment propensity of more advanced skill acquisition. This is a void in the literature that the current thesis aims to provide initial insight into.

Evidence from a neurophysiological perspective supports Reinvestment Theory from a range of electroencephalographic studies (Hatfield et al, 2004; Kerick et al, 2004; Haufler et al, 2002). Hatfield & Hillman (2001) stated that 'psychomotor efficiency' can exist regarding the communication between the verbal-analytical (T3) region of the brain and the specific frontal region of the right hemisphere. These areas of the brain can be held responsible for motor planning (Hatfield et al, 2004; Deeney et al, 2003). This psychomotor efficiency has been shown to exist within the sporting setting as Hung et al, (2005) showed that these areas of the brain were significantly stimulated when placed under psychological stress, resulting in the disruption of dart throwing performance. This psychomotor efficiency has also been shown in research



conducted by Crewes & Landers (1993) and by Steenbergen & van der Kamp (2008), whereby results showed unique EEG activation patterns complementing superior performance. Experts displayed activation from the verbal analytical regions of the left hemisphere prior to movement only and not during movement execution. Steenbergen & van der Kamp (2008) implied that this continual activation of this region of the brain is linked to movement failure, whilst other research has suggested that it is activation within this region which may be symptomatic of 'attention to action' (Jeux et al, 1997; Knight, 1994; Mesulam, 1990, Shallice, 1988). This kind of movement failure is supportive of the processing efficiency theory explored earlier in this chapter, whereby attentional effort could be misdirected or potentially overwhelm cognition under pressure. Ellmers et al (2016) analysed the effect of internalised focus of attention towards voluntary postural sway in younger adults. They surmised that although no differences were identified between high/low reinvesters, results did support the increased EEG activation of the verbal-analytical and motor planning brain regions when focus was explicitly internalised. They argued that younger adults can be assumed to utilise explicit verbal cues to control postural sway, providing they are explicitly directed to. This suggests that even well-developed skills such as gait and posture can be manipulated with increased activation of brain regions associated with reinvestment, providing explicit instruction. Further support of this notion was shown by Uiga et al (2018) whereby balance performance and control was associated specifically with movement specific reinvestment.

### 2.2.2. Reinvestment and Learning

Combined with the research above, there is also a substantial body of evidence concluding that accumulating large pools of consciously processed, task-specific knowledge should be avoided during motor learning, (Mullen et al, 2007; Masters et al, 2003; Maxwell et al, 2000; Hodges & Lee, 1999; Masters, 1992). The primary theoretical construct of this effect is the progression-regression hypothesis, (Jagacinski & Hah, 1988; Fruchs, 1962; Fitts et al, 1961). This hypothesis claims that relatively high-level performance can regress to early stages of skill development where execution is more reliable on verbal cues and explicit knowledge, (Masters & Maxwell, 2008). The progression-regression hypothesis fails to apply to effects on novice students or tasks as prior knowledge (progress) being a prerequisite for regression. However, if it is merely the process of regression that causes problems within the dynamics or processing of the task then this may account for such effects. The dissection of a real time control structure into segmented independent units has been discussed as a contributing factor to the disruption of motor performance, (Masters, 1992). It is theorised that once this division occurs, each unit must be activated individually requiring more attention. It is this division which slows performance and subsequently the transition between these units that may create an opportunity for error within information processing. This delay was not present when the control structure remained intact, and undivided (Beilock & Carr, 2001). MacMahon & Masters (1999) suggested that complex, serial tasks with many units are more likely to be subjected to reinvestment. This may explain why developmental skills which are heavily explicit in nature are subject to poorer performance under constraining factors.

Directing internal focus away from the explicit components of the skill can be beneficial. The constrained action hypothesis posited by McNevin et al (2003) explains when an external focus may benefit movement. An external focus of attention facilitates action by promoting automatic control of movement without constraining normative control processes. By adopting an external focus of attention (performance outcome), motor performance can be improved, whereas an internal attentional focus (executing movement parameters) leads to decrements in performance (Kal et al, 2018a; 2018b; 2013). Wulf (2013) reviewed research showing support for these effects within a wide range of sporting activity including basketball shooting (Zachery et al, 2005), golf (Wulf & Su, 2007), tennis stroke (Maddox et al, 1999), jumping (Wulf et al, 2010) and balancing (Shea & Wulf, 1999). None of these sports could be classified as high-risk under the risk classification outlined by Zuckerman (1994), therefore part of the current thesis aims to address this void by examining truly high-risk sports (aim 7).

Similar results have been shown within swimming using a lesser internal focus of attention but argued from an ecological constraints perspective. Komar et al (2014) instructed participants using an internalised analogy to infer more instruction than by simply learning the task via explicit instruction at a great internalised rate. Results showed that movement efficiency, swimming speed, and inter limb swimming coordination of the upper body was greater within the analogy group. This was attributed due to the ability of the participants educated via analogy, to create a more personalised, less constraining pattern of coordination.

Participants of expected high reinvestment adopting internal focus will inadvertently freeze or constrain various neuromuscular degrees of freedom,

(Zachery et al, 2005; Pijpers et al, 2003; Higuchi et al, 2002; Wulf, McNevin et al, 2001; Mullen & Hardy, 2000; Jones et al, 1998). This has received extensive support through the use of electromyography, suggesting changes in muscular activity such as increased co-contraction and decreased efficiency are associated with an external focus of attention, (Kal et al, 2018a; 2018b; 2013; Stoate & Wulf, 2011; Zachery et al, 2005; Vance et al, 2004; Pijpers et al, 2003; Wulf & Weigelt, 1997; Beuter et al, 1989; Beuter & Duda, 1985).

Recent studies have suggested an internally directed focus of attention to be substantially preferential amongst high reinvestment individuals, (Danneman et al, 2018; Kal et al, 2018a; 2018b; 2015; 2013). This was attributed to the patients continuing everyday preference towards an internally directed focus with ongoing stroke rehabilitation. This is in line with Maurer & Munzert's (2013) research showing that direction of focus is confounded by preference and an important factor in determining the optimal focus of attention strategy. Maurer & Munzert (2013) proposed that if an attentional strategy is frequently used enough, it can become integrated within the skill posing little threat to the automated skill execution. This strategic approach could apply to acquisition techniques such as discovery learning and analogy-based instruction, with their effect on performance (discussed later in this chapter).

#### 2.2.2.1. Measuring Reinvestment

The component of reinvestment was originally measured through the Reinvestment scale devised by Masters et al, (1993). The scale consisted of twenty items which previously existed within other validated scales. Each of the constituting scales had been associated with an internally directed focus of attention towards the mechanisms of controlling movement. The scale

consisted of 12 items from the Self Consciousness scale (Fenigstein et al, 1975), 7 items of the Emotional Control Questionnaire (Roger & Nesshover, 1987) and finally 1 item from the Cognitive Failures Questionnaire, (Broadbent et al, 1982). The basis of using such a range of items was derived from the belief that cognitive failures result from an inherent flaw and are the origin of deautomisation. Masters et al, (1993) also suggested that if disruption occurs easily within different individuals, then the tendency to rehearse may be an indication of an increased temperament to control movements. The scale was created through a series of studies that identified the twenty items as a reliable factor for reinvestment. The results supported the scale with strong reliability. Subjective analysis and reinvestment scores resulted in a strong correlation ( $r=0.64$ ,  $p<0.01$ ), along with a strong negative correlation between reinvestment score and performance under pressure.

Following Masters (1993), research has supported the use of the reinvestment scale with evidence and increased reliability within a range of sporting environments; baseball (Gray et al, 2017), golf (Maxwell et al, 2017; 2006; Malhotra et al, 2015), hockey (Jackson et al, 2006), and soccer (Chell et al, 2003). The main underlying criticism of this scale however, is the lack of specification to direct movement, potentially hindering the overall validity of the scale. The scale fails to actually measure the process of reinvestment directly but merely assemble conceptually linked predictors of the process, (Jackson et al, 2006).

From this critical analysis, Masters, Eves and Maxwell (2006) formulated the Movement Specific Reinvestment Scale (MSRS) in order to amend the aforementioned potential weaknesses. The MSRS modified the existing 20 items (derived from the original reinvestment scale) plus 4 previously

eliminated items. This was performed to reform the objectivity of the scale to be directly related to the movement process of the learner. The MSRS consists of a final 10 of the original examined 24 items previously. Eight items were removed because of uni-directional answers, and a further 6 being eliminated due to loading issues within a principle axis factor analysis. The remaining items confirmed the existence of two factors each consisting of five items. Factor 1 was labelled as 'movement self-consciousness' suggesting an awareness about the impression given in the way they move. This factor was shown to account for 29.73% of the total variance explained, along with high test-retest ( $r=0.67$ ) and internal ( $r=0.78$ ) reliability. The second established factor characterised contemplation of the movement process, regarding the mechanics of the movement from past, present and future motor activity. This factor was again proven high in both test-retest ( $r=0.76$ ) and internal ( $r=0.71$ ) reliability, along with a marginally smaller account for the total variance explained, (29.65%). The original MSRS was conducted using a factor analysis on yes/no items; these were then converted into tetrachorics in order to compute the correlational matrix etc. In order to increase the range of scoring possibilities, the response format has now been changed to a six-point Likert response.

The more recent version of the scale is the, Decision-Specific Reinvestment Scale (Kinrade, et al 2010b). This consists of a total of thirteen items encompassing two factors regarding the conscious monitoring of making a decision (*Decision Reinvestment*) and the focus of negative evaluations of previous poor decisions (*Decision Rumination*) (Kinrade et al, 2010b). The scale showed a high correlation ( $r = 0.74$ ) when compared with coaches'

ratings of the same participating individuals' propensity to suffer under pressure (i.e. task accuracy and outcome measures).

Research to date has focussed on using such scales to measure reinvestment and assessing the impact of stress on performance (Masters 1992; Maxwell et al, 2006; Poolton et al, 2007; Gucciardi & Dimmock, 2008; Masters et al, 2008a; Masters et al, 2008; Kinrade et al, 2015; 2010b; Malhotra, et al, 2015; van der Graaff et al, 2017; van Ginneken et al, 2017). Based on the relatively closed nature of environmental predictability that exists within high-risk sports, many of the decisions have been made prior to participation. Specific tricks or routines have been developed and decided before the performer begins (Way, 2010). It is understandable that the controlling movements determine how successful the movement is performed and therefore minimise the physical risk concerned with failure. This emphasis on the controlling movements may possibly influence the extent of subsequent reinvestment. It is for this reason that the current thesis has chosen to use the Movement-Specific Reinvestment Scale (Masters et al, 2005) over other available scales, previously mentioned.

The current thesis aims to explore the link and potential confounded effect of reinvestment during high-risk sports as an original concept as this has yet to be researched. Learning whilst exposed to stress has been researched extensively with multiple stressors, yet physical threat in sport as a stressor has yet to be examined. High-risk sportsmen are not only exposed to physical threat, but also identify it as something they strive to overcome (Way, 2012). Physical threat is considered 'part of the game' (Cole, 2012), and the research discussed regarding reinvestment identifies attentional bias towards movements as debilitating towards performance in high stress situations. Successful performance under stress is dependent on using learning

techniques that can produce robust performance under stress (Lam et al, 2009a). The potential reinvestment experienced by high-risk sportsmen is considered declarative knowledge and is the key focus of debate between implicit and explicit learning interventions. The next section will review the variety of methodologies used to induce implicit and explicit learning, and their link to successful performance under stress. It is one of the aims of this thesis to apply these interventions for the first time in high-risk sports, in order to identify if the effects found can be applicable to examples of this ever-growing sporting culture.

### **2.3. Implicit / Explicit learning strategies**

The current sporting environment places various demands on the athlete's cognition. These demands range from physiological actions, along with both temporal and psychological constraints. This requires the athlete to have a superior foundation of learnt skills to depend on, whilst exposed to strenuous factors. Research has shown that learning can be initiated via implicit or explicit means, (Williams et al, 1999). Implicit learning is defined as the acquirement of knowledge, undertaken independently of conscious processing, and without the formation of explicit knowledge regarding the task, (Masters, 1992). Explicit knowledge is defined as the attainment of knowledge through active processing by systematically arranging the presented information so that execution of the skill can occur, (Orrell et al, 2006). The defining characteristic between these two learning processes is the degree of conscious involvement during the learning process, (Gentile, 1998).

Research over the past thirty-years has shown there to be a significant advantage in acquiring implicit knowledge over a more explicit option whilst



under stress. Implicit learning has been shown to be robust under conditions of psychological stress, (Gucciardi & Dimmock, 2008) and temporal constraint (Masters et al, 2008a). Physiological stressors have been investigated showing implicit learning is also robust under physiological exhaustion through both aerobic (Masters et al, 2008b) and anaerobic fatigue, (Poolton et al, 2007a) and also sleep deprivation (Diekfuss et al, 2018). Performance that employs explicit processing has been found to decrease under conditions such as these. This is important as many of these conditions are reminiscent of the sporting environment. If explicit means the cessation of learning facilitation within the sporting environment, it is vital that learning adopts a more implicit approach, as it is the more ecologically valid and effective coaching method.

Attempts to understand the nature of implicit learning have been undertaken through different methodologies, following the same core theoretical principle. When skills are successfully learnt, they are stored successfully in the long-term memory. This can then be recalled for reference when recreation of the skills is required (Schmidt & Wrisberg, 2004). Implicit and explicit instruction begin to differ in effectiveness as a result of working memory (Baddeley & Hitch, 1974). Hypothesis testing takes place within the central executive of working memory (mentioned previously in this chapter) (Baddeley, 2007). This process involves the performer comparing the current performance to that of past experiences stored within the mind. The use of explicit hypothesis testing has been criticised as being inefficient, attention demanding and slow, (Anderson, 1982). Consequently, performance becomes substantially affected due to inhibitions within information processing. When skills are explicitly acquired this comparison between past and present movements requires conscious effort posing a strain on the movement production. This strain could

be similarly effective to overwhelming effects proposed in threshold models regarding anxiety, previously mentioned in this chapter.

Implicit processes are created through unconscious processing, removing the issue of active hypothesis testing at a conscious level. This diminishes the capacity for 'paralysis by analysis' as seen in explicit learning. This is supported within multiple areas of cognitive psychology. Henry & Rogers (1960) proposed a theory of neuromotor co-ordination which viewed the mind as a 'memory drum'. This suggests that movements under excessive conscious manipulation lead to an interference within motor programming, causing a debilitating effect on the coordination from increased reaction latency. Klatzky (1984) has commented on the principle that awareness of action decreases with practice, becoming attentive to specific movements of the skill, resulting in impaired execution of the skill. This issue has been described as a process of 'deautomatization' whereby the skilled behaviour may regress back through the learning process, due to directing attention toward the action itself and not to the execution of the action as a fluid activity within the situation, (Deikman, 1969). This effect was found in more recent research by Kinrade et al, (2015) when skilled basketball players showed performance impairment during increased task complexity whilst performing well known skills. This effect was found to be significantly associated by the reinvestment measures obtained as a valid prediction of performance under task complexity.

As mentioned earlier, there are several different ways of inducing implicit skill learning. The following methodologies have all been shown to successfully impair active hypothesis testing on a conscious level, resulting in any information being acquired implicitly. The remainder of this section will review both the practicality and supporting research for implicit learning

strategies. These methods range from including secondary tasks as a means of distracting participants from the core skills being learnt, to the removal of feedback to limit comparisons between attempts being performed previously. Finally, the introduction of using analogies to convey information, in attempt to minimise declarative knowledge will be discussed.

### 2.3.1. Secondary Task Loading

Secondary tasks simultaneously employed during movement acquisition have been used to induce implicit learning. This is based on the principle that as long as the conscious activity is directed towards the secondary task, then no active hypothesis testing can occur regarding the primary task (experimental focus) (Masters, 1992). A commonly used secondary task is repeated word rehearsal. The repeated word rehearsal is hypothesised to dominate the articulatory response control processes resulting in the disruption of the storage and rehearsal properties through the presentation of the unattended speech. Thus, gaining direct access into the phonological store resulting in similar dysfunction (Salame & Baddeley, 1982; 1987; 1989).

Several studies have employed the use of secondary tasks resulting in a mixed opinion towards the effectiveness of such an approach, (Tse et al, 2017a; 2017b; Kinrade et al, 2015; Rendell et al, 2011; Dienes et al, 1991; Masters, 1992; Hardy et al, 1996; Bright & Freedman, 1998).

Masters (1992) conducted research supporting the use of such secondary tasks. In this study, participants executed the skill of a golf putt whilst under the instruction of either implicit or explicit-based guidance. The implicit guidance was brought about through the employment of random letter generation in

order to manage the conscious activity. Afterwards, both groups underwent a competitive based execution of the skill in which pressure was induced through the form of financial reward and the apprehension of evaluation from a professional golfer. Results showed that novices generating random letters, gained little to no explicit or recallable knowledge of the putting skill being performed, compared to the discovery learning and explicitly instructed condition. This was identified as a defining characteristic and in turn confirming the existence of implicit learning. Masters (1992) also confirmed that implicitly learned performance remained robust under the psychological stress of a financial reward and the apprehension of professional evaluation.

Critical of these findings, Hardy et al, (1996) has suggested that the robust performance of the implicit group may be caused by the removal of the secondary task during the stress phase. Upon replicating the study with this modification, Hardy et al, (1996) found that robustness remained constant despite continued random letter generation during the stress phase for the implicit group, providing support for the earlier argument proposed by Masters (1992). Contrasting findings have been noted by Bright and Freedman (1998) who asked the same question using a similar design but failed to find maintained robustness during the stress phase. These findings were potentially flawed as a direct comparison, as they failed to replicate Masters' study with differences including; only 160 trials compared to 400 measured by Masters, in addition the putting was on a flat surface and 200cm distance whereas Masters was on an incline of 1:4 and 150 cm away. These may have become confounding variables responsible for any differences in findings. Issues such as number of trials conducted, acquisition and retention periods

within learning literature will be discussed later in this chapter, and subsequent potential threats to the respective findings.

There is also a potential issue with Bright & Freedman's (1998) definition of a novice performer. According to the study, all performers were naïve to the sport and therefore had little to no previous experience. This was only true that no experience had occurred in the previous twelve months. Prior to this period individuals' experience could have included a varied range of talent allowing for prior knowledge to confound the results, by providing some individuals with previous knowledge to perform the task giving a biased advantage. Even though this goes against the aim of the actual study, it does however provide further strength to the credibility of employing secondary tasks. The issue of defining a novice will be discussed later in this chapter, along with other critical reflections on learning literature.

Regardless of having an easier task to learn and possible previous knowledge, the creation of implicit learning via secondary task loading techniques have failed to succeed in some research. This use of secondary tasks failed to show significant effects on performance in the study conducted by MacMahon & Masters (1999). Subjects exposed to random letter generation tasks whilst putting were unaffected by this constraint (secondary task), and experienced explicit learning as accumulation of explicit knowledge failed to be restricted by the phonological loop. It was concluded that secondary tasks are unable to prevent the accumulation of explicit knowledge, (MacMahon & Masters, 1999). More recent research using mental arithmetic has found this variation of secondary task loading to be successful. Tse et al (2017a: 2017b) successfully induced implicit learning via analogy and used the secondary task of reverse counting. Similarly, Denneman et al (2018) used auditory tone recognition

within the transfer test, debilitating the internally focussed monitoring of participants' gait. The reasoning behind the success of these secondary loads (reverse counting and tone recognition) whilst random letter generation are less effective is unclear. Anecdotal accounts suggest that individuals can co-ordinate their movements rhythmically to background music, often without intending to, and even without attending to the music consciously (Leow et al, 2018). Tones, and recitation of numbers in a standardised reverse pattern could be perceived as musical, and potentially attended to unconsciously. Theoretically, the phonological loop may therefore successfully restrict the accusation of explicit knowledge as hypothesised by MacMahon & Masters (1999).

Despite these differences in opinion toward the credibility of such secondary task loading, the idea of using secondary tasks is potentially flawed by practical limitations. It is not feasible for coaching to occur, directing attention towards information that is not relevant such as random letter generation or counting backwards in denominations of three. Although this can be accomplished initially, it is not plausible on a long-term basis. This is a less ecologically valid approach to tuition as the coaching environment should be a true reflection of the sporting environment in order to allow for optimal performance, (Gibson, 1986). With the credibility of secondary task loading being questioned in a sporting context, two more methods have been employed to stimulate implicit learning. Both errorless learning and no-feedback learning work on the same principle by modifying the programming element of motor production via different means.

### 2.3.2. Learning with reduced feedback

Errorless learning has been proposed to imply implicit content as explicit processes are able to detect and eliminate errors during learning. Implicit processes are incapable of this detection as encoding of frequency information is recorded regardless of incorrect or correct outcome, (Baddeley & Wilson, 1994). Therefore, implicit processes store both failure and success, whilst explicit eliminates failure and stores only success. This may affect the retention of past experiences of performance, affecting the ability to recall how to correct a failing movement. As no unsuccessful errors are stored to actively test against, this eradicates the accumulation of explicit processing leaving only learning of implicit nature.

Studies have used errorless learning by slowly increasing the difficulty of the task at such a rate that little to no errors are committed to memory, (Maxwell et al, 2017; Masters et al 2008a; Masters et al, 2008b; Poolton et al, 2007a; Masters et al, 2002; Maxwell et al, 2001). It has been noted that such a coaching method can create problems concerning motivation and concentration as the tasks can become repetitive quickly and may not easily be reduced to such a simple measure instantly. It is also important to consider that using such a method still lacks ecological validity within a sporting environment. The tasks may be classified as 'open' where control could be manipulated by an external stimulus, and not the performer. If this is the case, then the errors may be produced as a result of the actions of others. If this is the case, using such a coaching method will render the performer unable to correct their movements based on the outcome of others with the maximum certainty of success. Regarding the performance proficiency perspective of highly skilled motor production, this is a key component of motor skill

production and is highly valuable to the performer for successful performance, (Schmidt & Lee, 2013). It is not possible to train each situation for external factors in such an errorless manner and will therefore leave the performers possibly inadequately trained for competition. Successful learning is dependent on the ability of adaptation to the performer's environment (Gibson, 1986). Errorless learning potentially fails to provide the fundamental information required for ecologically valid understating the consequences of our actions.

No-feedback learning resides on the original principle by disrupting active hypothesis testing. This technique was used by Maxwell et al (1999) by suppressing the accessibility of knowledge of results by visual and audible feedback. The required skill was a putting task whereby vision of the targeted hole was occluded from the performer. The participants were only aware if the shot was successful or not, with no other feedback. This removed the ability to actively test hypotheses, as there was minimal information for the performers to focus or modify their actions on. By removing the feedback, the formulation of a reliable hypothesis is prohibited and cannot be available for comparison in active hypothesis testing theoretically inducing implicit learning conditions. The study however, failed to produce implicit learning as the use of proprioceptive feedback allowed for active hypothesis testing to occur. This demonstrates the adaptability of the learning process, identifying the need for a technique concerned more with misdirecting attention, rather than arresting it.

The above techniques of errorless learning and no feedback learning are not applicable to high-risk sports. Errorless learning can be difficult to replicate within high-risk sports (e.g. skateboarding) as many of the skills involve aspects of speed, velocity, and coordination that are unrealistic to sustain



control of, in an attempt to remove errors in performance. The use of harnesses is possible, along with larger equipment to enable certain skills, but using such equipment will inherently alter the movements reducing the ecological validity of the learning process. Many of the skills involved in such high-risk sports (snowboarding, BMX, skateboarding, etc.) involve complex whole-body movements that are interdependent on coordinating the movement as a whole. By minimising one single aspect of the skill this may alter the overall dynamics of the movement, becoming invalid in performance.

No feedback learning within high-risk sports lacks practicality. Using a 'trial and error' approach within a physically threatening environment is ethically inconsiderable as failure may result in serious injury. It should also be noted that failure of the skill within such environments is impossible to withhold from the performer given the nature of the skills and the abundance of proprioceptive feedback available to the performer. Manipulating the performer or skill, lacks validity as this will not truly represent the targeted skill within the sport. Focus should be on the manipulation of the instructions or delivery method as accomplished by analogy learning, to maintain the validity of the skills being learnt.

It is for the above reasons that other means on inducing implicit-based learning have been chosen to be implemented within the current thesis. Despite these limitations, the methodologies have provided significant support for the development and understanding of implicit learning. The research based from these methods have provided crucial insight into the development of the design of the relevant experimental research, warranting review.

### 2.3.3. Analogy Learning

The research reviewed so far in this section has focussed primarily on controlling attention directly, either by suppression or manipulation. These methods have succumbed to complications in one aspect or another, highlighting the need to redirect attention in a more passive manner.

Based on this requirement, the approach known as Analogy learning has been developed. This method aims at using a metaphor to deliver the information regarding a skill. This should direct the focus of attention from the performer to that of the metaphor, rather than focussing the attention on the specific mechanics of the skill itself, (Liao & Masters, 2001). This misdirection will divert the formulation of explicit knowledge towards that of the metaphor and not the movement. As the analogy requires similar movements to the skill, the end product of the skill can still be executed. This approach has demonstrated robust implicit learning successfully (Tse et al, 2017a; 2017b; Tzetzis & Lola, 2015; Schucker et al, 2013; 2010; Lam et al, 2009a; 2009b; Masters et al, 2008a; Poolton et al, 2007b; Liao & Masters, 2001).

One limitation of this approach however is the ability of progression through to the latter stages of learning. As little explicit knowledge is acquired by participants, there is also limited opportunity to understand the actions and therefore progress beyond their current level. The use of such conscious awareness of the action can be needed for progression, (Bennet, 2000). Another limiting factor is the extent to which a valid analogy can be created. The first skill acquisition study (chapter 4) of this thesis will focus on novice participants. Using an analogy with novice participants can be problematic, firstly due to the complexity of the movements involved in the skill. Complex

full body movements have yet to be instructed using analogy learning. Many of the skills in high-risk sports involve aspects outside of the performers control (gravity, momentum) along with simultaneous inter limb coordination. Attempting to oversimplify this collection of movement parameters can easily become convoluted and may further complicate the understanding of a complex, whole-body movement.

Secondly, many of the movements are dependent upon one another and are independent of common movements. Standard skills such as jumping or kicking are not applicable in many high-risk sport (skateboarding, snowboarding, and surfing). These sports require the performer to approach skills differently to others, and force performers to reevaluate how to 'walk again' (Way, 2012). When analogies have been used in past research, although participants were considered novice, they were being asked to develop based on common understanding that had already been mastered; jumping (Tse et al, 2017b), hand-eye coordination (Poolton et al, 2005; Liao & Masters, 2001), and throwing (Lam et al, 2009a; 2009b). Many of these skills already had some aspect of knowledge that has become automated. Therefore, the current thesis will only aim to implement analogies from the second skill acquisition study (chapter 5) onwards. This is because many of the base aspects of the chosen sport of skateboarding are developed, providing a foundation for further complex skills to be built on at a more advanced stage of learning.

Research in the past has used such analogies as 'following the hypotenuse of a traced triangle, drawn with the paddle' in order to convey execution of a topspin serve in table tennis (Law et al, 2003; Liao & Masters, 2001). Lam et al (2009) found the analogy "shoot as if you were trying to put cookies into a

cookie jar on a high shelf" (pg. 344), yielded successful learning and significant performance under stress within basketball free throw shooting, whilst Schucker et al (2013) instructed participants to 'imitate a pendulum' in golf putting. The current thesis will employ similar abstract analogies focussing on lower limb manipulation by encouraging participants to 'draw a tick (symbol) with your toes'. This has been shown to be a valid approach to initiating the required spinning motion in the chosen skill (Cole, 2012). This will be the first known research to employ an analogy whereby the subject is in transit and not executing the skill whilst stationary.

The use of procedures such as fractionation and segmentation have been found to produce significant improvements in memory and learning, (Wightman & Lintern, 1985; Whaley & Fisk, 1993) by breaking a complex skill down into more manageable segments. Once one of these segments is mastered, then the performer can move onto the next. However, these methodologies have been shown to be unsuccessful on rapidly discrete tasks (Lersten, 1968; Schmidt & Young, 1987), whereby dissection of these movements leads to arbitrary parts which are unable to meld together again to form a fluid movement. It is these specific forms of movement that are used within the skills of sports such as skateboarding, BMX, and other gymnastic activities.

Based on the analysis of previous methods, the introduction of another method is proposed in the first learning study (chapter 4) study. By providing the individual with minimum knowledge regarding the task, it will limit the degree of explicit formulation. It is hypothesised that by limiting the explicit formulation through minimal explicit instruction, the remaining parameters will be conducted implicitly by following through with the listed parameters. This will therefore provide some explicit processing to be used via progression into the

latter stages of learning. This allows the performer to become partially aware of their actions yet will cease to impose a significant strain on attention capacity through minor hypothesis testing. Following that study, the focus of skill acquisition will turn towards more experienced individuals. Chapters 5 & 6 will examine the use of different learning methodologies on more advanced, experienced individuals, and then professional athletes respectively. The skills acquired during testing will be a development and extension of core, root skills learnt at a lower level and stage of learning. This will make analogy learning to be more appropriate, and still theoretically effective despite the increased complexity of the movements, given that these skills are performed by athletes of a higher calibre.

Coaches not only consider the design of the instructions given, but also the delivery of the information. The concept of live versus video demonstration is significantly important to a coach and has been debated within research. Observational learning is accomplished by viewing and copying the behaviour of others and has become the centre of many coaching practices. Research regarding implicit/explicit processes provides insight as to the nature of the instructions (e.g. analogy over detailed instruction) but has yet to link these instructions with the delivery method of these instructions. Coaching is common using live models, however with the accessibility of social media, internet and communications, video coaching is becoming increasingly popular. Video instruction offers potentially more practical and accessible means of acquiring information. Research to date, has not examined the use of implicit/explicit learning with the combined effect of the affectivity of live/video coaching. Demonstrations are the most frequently used tool to convey information across to students, (Williams & Hodges, 2005). Examining

observational learning processes (be it implicit or explicit) via live models or video can provide insight to two important aspects of coaching; Firstly, can either method convey both implicit and explicit learning via observations? And secondly, is one form of presentation more effective at establishing robust learning. The next section of this chapter will focus on research regarding a crucial aspect of any coaching catalogue; observational learning via demonstration.

## **2.4. Observational Learning**

By watching demonstrations, observers aim to adapt their behaviour, matching the movements of others via interaction. This process is known as observational learning (Williams et al, 1999). Observational learning is linked to the concept of imitation that involves adaptation of one's movements to that of another. Imitation can be found in two forms; matched dependent and copying (Miller & Dollard, 1941). Matched dependent imitation involves reproducing a response blindly as a result of reinforcement without understanding or consideration of purpose. Copying follows the guidance of others to actively manipulate your own behaviour based on motivating goals. Copying does not require the demonstration in order to complete the movement for every reproduction of the skill, depending if the skill can be committed to memory successfully. It is understood that through using imitation within observational learning, parameters of the movements can be committed to memory and understood, so that the movement can be recreated relative to the subject performing it, (Baldwin, 1920).

Research using functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) has shown a link between presentation of a

stimulus and the recreation of observed behaviour. This link is a shared neurological region of the brain from which both actions derive. Developments in brain imagery have confirmed that imitation evokes activity in the area of the brain known as the 'mirror-neuron system', (Chong et al, 2009; Calvo-Merino et al, 2005; Rizzolatti et al, 2001). This area exists through a complex system of neurons spanning the occipital, temporal and parietal visual areas along the two cortical regions of the brain (Rizzolatti & Craighero, 2004). Neurons with this mirror characteristic have been found in the premotor area (F5c). This area completes a circuit between the posterior parietal area of the brain which has also been found to contain neurons with mirror-like properties (Fogassi et al, 2017; 2005). The human mirror system is believed to contain the above-mentioned neurological regions along with an added component known as the inferior parietal lobule (IPL) and receives sensory information from the superior temporal sulcus (STS). This specific neurological landmark is known for processing visual stimuli and configuration of motoric parameters of movement, (Keysers & Perrett, 2004; Jellema et al, 2002; Allison et al, 2000).

With this in mind, the combined area known as F5c is known for multitasking in both the planning and production of motor actions (Cattaneo & Rizzolatti, 2009; Rizzolatti et al, 1988), along with the coupling of observed actions into a versatile visio-motor interface, through the high order processing of the premotor cortex (Schubotz & von Cramon, 2004; Nishitani & Hari, 2002; 2000). Further studies have shown that when observing general movements, the human mirror neuron system becomes activated, (Fogassi, 2017; Maranesi et al, 2017; Maeda et al, 2015; Casile, 2013; Wheaton et al, 2004; Maeda et al, 2002). Based on these findings, Molnar-Szakacs et al (2005) underwent a reanalysis of multiple fMRI studies providing further support for the

understanding of mirror neuron properties. The properties that a mirror neurone possesses, allow an individual to pair observed behaviours to those of goal directed neural representations through high order processing via the dorsal and ventral areas of the pars opercularis, (Casile, 2013; Vogt et al, 2006; Molnar-Szakacs et al, 2005; Buccino et al, 2004). The neurological process of observational learning has been outlined by Iacoboni (2005) through three stages; (1) visual stimuli enters the STS via the ventral stream of information, (Ungerleider & Mishkin, 1982) followed by (2) coding of the desired motor response needed to achieve this goal in the mirror neurone system, which (3) is sent back to the STS for perception-action coupling to the observed action.

The central theoretical construct of observational learning is the Social Cognitive Theory, (Bandura, 1986). This theory suggests that co-ordination between four sub-processes; attention, retention, behavioural production and motivation, inherently govern the observational learning process. The component of *attention* directs the individual's perceptual system in order to selectively attend and thus extract distinctive features of the environmental context in order to compare previous experience to the current situational demands. This is a similar understanding to that of hypothesis testing, mentioned earlier regarding formulation of explicit knowledge. The component of *retention* facilitates memory by reconstructing the observed act through concepts known as labelling, coding and imagery in order to aid in the *motor reproduction*. The principal put forward by Sheffield (1961) claims that by observing the movement of others, the individual stores a 'perceptual blueprint' of the task and then uses this 'blueprint' as a means of symbolic storage within the mind. Finally, *motivation* is included as the extent the subject is inspired to carry out the task.



The concept of a 'perceptual blueprint' is also concurrent in perceptual training. Goldstone (1998) proposed four mechanisms which facilitate the acquisition of knowledge through perception. The first of these mechanisms is *attentional weighting* whereby the subject creates a hierarchy of stimuli to which they shall apply focus, similar to that shared by the Social Cognitive Theory, (Bandura, 1986). This is supported by the concept of *stimulus imprinting* where specific stimuli force the observer to create specific receptors for set stimuli. The performer then calls upon these receptors when the stimuli is present within their perceptual field triggering the movement. The remaining mechanisms; *differentiation* and *unitisation* follow the concepts of splitting (differentiation) and constructing (unitisation) complex stimuli within the environment. This allows for understanding of the individual complexities of certain stimuli, and also the relationship between the variables as a combined entity.

Within observation learning literature, there is a growing debate as to the specific stimuli that can attribute reaction via attention. Wohlschlagel, et al (2003) has led to the theory of Goal Directed Behaviour stating learning as a result from demonstrations is guided by cognitively specified goals regarding reproduction of the observed action. This observed action is cognitively reconstructed into a hierarchy of goals and sub-goals. The main goals are transferred to the observers' motor system, whereby the perceived main goal triggers the motor routines most strongly associated with achieving the goals in their own motor repertoire. Research supporting this has been conducted on both children (Gattis et al, 2002; Bekkering et al, 2000) and adults (Wohlschlagel et al, 2003); showing that although the distinctive motor pattern is not recreated identically, the end result or goal of the movement is maintained.

This process of priming is based on conceptually perceived actions and can be found within the Ideomotor Theory (Prinz, 2002; 2005) and Associative Sequence Learning, (Heyes, 2005). The Ideomotor theory claims that voluntary actions are initiated by means of anticipated representations of the produced environmental effects. By observing the action of another, an alternative perceptually driven occurrence of initiated action can be produced. This shows similarity to the previously mentioned Goal Directed Behaviour theory, (Wohlschlager et al, 2003) and also in the Associative Sequence learning approach. The exposure of a sequential action results in the formation of distinct representations. This is produced by linking each of the novel sequences to existing familiar action elements via existing associations. When these associations are triggered through repeated observations, each of the constituting elements activates a corresponding motor representation. It is this repetitive sequential activation forming links, which is classified as motor learning, leading to an improved potential of effortless imitated movement. This however, fails to explain the assimilation of truly novel tasks, to which no possible previous association can exist. The existence of another contributor that potentially governs the thought process externally may be more feasible. The current thesis aims to employ the observational learning concept through analogy and explicit instruction replicating a typical coaching scenario. By understanding the sequential nature of linking representations together, this can inherently attribute to any potential differences derived from different learning methodologies. The notion of overwhelming working memory and attentional focus can be linked to the increased representations to perceive, interpret and process in a complex whole-body movement. Movement

involving gross actions of the whole body, whilst in transit have yet to be examined regarding observational learning and implicit skill acquisition.

Research has examined specific sports regarded as action adventure sports and are defined as sports considered to involve high physical risk (Buckley, 2015). Immonen et al (2017) suggests that behaviours including movement production and subsequent learning are dependent on the demands that emerge from the interaction between the performer and environment. Research supports the idea that participants are bodily situated within their physical environment (Bicknell, 2016) emphasising the influential role of environment on learning. Knowledge has been shown to be created through bodily movements in relation to the physical environment (Hollett, 2017; Bicknell, 2016; Langseth, 2012; Kellet & Russell, 2009).

Key constraints have been identified categorising specific constraints placed upon the individual responsible in shaping the cognitions, actions and decision making processes; environmental, individual, and task (Newell, 1986).

Environmental constraints are inclusive of physical (e.g. weather or gravity) and sociocultural (e.g. values or cultural norms) (Davids et al, 2013). Action adventure sports offer mastery within unique unpredictable environmental constraints (e.g. ocean swell, thermal updraft, current flow) increasing the high physical risk nature of such activities (Immonen et al, 2017).

Individual constraints consist of structural characteristics such as height, weight or body shape and may also include the psychological characteristics (e.g. emotions, motivations and cognitions) of the performer (Davids et al, 2013; Davids et al, 2008; Booth & Thorpe, 2007). Research within action adventure sports has shown psychological factors such as fear, anxiety, beliefs

and motivation to significantly affect the perception of the environment (Lawrence et al 2014; Brymer & Schweitzer, 2013; Sanchez et al, 2010).

Task constraints include specific rules, task goals, objectives, and instructional order (Davids et al, 2013). Action adventure sports are not primarily controlled by organisational frameworks or regulated competitive structures (Ojala, 2015; Davids et al, 2013). This differentiates these kind of sports as they are not categorised by the same traditional concept of rule based task constraints (Immonen et al, 2017). Aesthetic aspects such as personality of style (i.e. kinaesthetic personalisation whilst meeting task goal) and creativity (i.e. innovation, novelty and originality) are highly regarded in judging performance (Thorpe, 2017; Ojala, 2015; 2014). Research suggests that the functionality of skill within this sporting culture is dependent on the interaction between specific task and personal constraints such as collective sociocultural agreement/interpretation and originality (Immonen et al, 2017).

Behavioural characteristics such as creativity and innovation impose crucial task constraints during performance and subsequent learning (Immonen et al, 2017). It is therefore feasible to suggest learning interventions that maximise available affordances to explore action possibilities, may provide a more effective setting for learning to occur. Implicit learning techniques (e.g analogy learning) may provide differences in creative freedom and the subsequent affordances required to perform. The use of implicit/explicit learning strategies have yet to be examined specifically within action adventure sports whereby these unique constraints exist within an ecological perspective toward movement production.

The ecological perspective details theories such as Dynamic System, (Muchisky et al, 1996) and Relative Motion, (Scully & Newell, 1985). Within the perceptual landscape (or demonstration), it is believed that individuals treat perception as whole rather than part. This is to ascertain the case-specific normal context by viewing an isolated element, and the variations in movement outcome measures that may occur (Clark & Crossland, 1985). It is the environment imposing constraints on both the individual and the demonstration, thus inherently influencing the correct coordination of the body to succeed in reproducing movement. Based on this concept the learner will attempt to understand the varying degrees of freedom surrounding the coordinated pattern as a means of configuring the motor system, (Thelen, 1995). It is observation that facilitates the searching pattern for a task solution by means of attractors within the perceptual-motor workspace. This enables the observation of a demonstration to guide the search for such solutions within the workspace to successfully reproduce the required motor task (Al-Abood et al, 2001).

According to the ecological perspective, a relationship exists between the different aspects of the movement being demonstrated, leading to the theory of Relative Motion (Scully & Newell, 1985). It is hypothesised that the perceived relative motion between the co-ordinating limbs during the demonstration is crucial for observational learning to occur. Scully & Carnegie (1998) confirmed this hypothesis by instructing ballet sequences through the presentation of point light displays whereby the relative motion was made salient through video playback. It was shown that those who learnt under the point light display condition performed significantly better than those who did not.

Research has shown contrary results as the unaltered demonstrations significantly improved performance over that of point light displays (Hayes et al, 2007; Horn et al, 2002; Al-Abood et al, 2001; Romack, 1995). Horn et al, (2002) reported no significant differences between the use of point light displays, video playback and a control group. The principles of relative motion failed to be conveyed effectively, causing no significant differences on the variables of movement form or outcome. The strategies used by the groups on the approach were shown to be significantly different. This confirms the effect of relative motion as the movement parameters were in fact aided by demonstrations as the inter-limb coordination of the lower body was significantly altered. From this it can be understood that demonstrations are successful at conveying general, strategy-related features of the movement, as opposed to the original higher-level perceptual features, (Hodges & Franks, 2004).

Discrepancies regarding this fact (i.e. strategy-related movement features) have been discussed pertaining to differences in task constraints. Constraints such as the variability of the outcome goal have been shown to influence effectiveness of point-light displays (Al-Abood et al, 2001). Variability of constraints allowing the individual to personalise the movement and still meet the outcome goal, which may be important regarding complex whole-body movements such as skateboarding and other high-risk sports. These sports are scored with consideration to an artistic performance element. Scores can be significantly altered based on the artistic personalisation of the skill being performed (Way, 2012).

Other task constraints such as availability of feedback (Horn et al, 2005) and task goals (Hayes et al, 2007) have failed to show advantageous effects over

the adoption of point-light display when compared to unaltered demonstrations. The effectiveness of such unaltered demonstrations combined with delivery method (e.g. video/live and implicit/explicit) has yet to be examined. This is an important relationship to investigate. The delivery of information can affect processes such as attention and memory in different ways, in relation to information processing and observational learning.

There is a collection of research that considers the degree of attention or attending to stimuli as a reciprocated variable. Cognitive psychology has begun to explore the effect of different variables, and their influence on the component of attention or the ability to establish motivation, in order to retain information. Research regarding gender has reported that matching the gender of the model and the observer, has shown a facilitated effect on learning, (Feltz & Landers 1977; Gould 1978; Gould & Roberts, 1982; Gould & Weiss, 1981; Griffen & Meaney, 2000). This supports the motivational and attentional aspects of the observer, as models of same gender allow the learners to become more comfortable and therefore motivated to learn along with the model.

Research has shown that the age of the observer has shown to be of significance for effective learning through demonstration. A meta-analysis (n=55) produced by Ashford et al (2007) confirms that observational learning is more successful for children compared to an adult population. Suggestions into the actual goal in which the learner attends towards, whether it is the outcome goal as opposed to the intrinsic dynamics of the skill have been put forward to explain this difference. The effect of the model's skill level is of debate within the literature, as research suggests that observing a skilled athlete would be more beneficial than an unskilled counterpart (Lirigg & Feltz,

1991; Landers & Landers 1973), whilst studies such as Pollock & Lee (1992) have found no difference. Pollock & Lee (1992) explain these findings through Adams' (1971) closed loop theory and Schmidt's (1975) Schema theory, which require feedback and copious volumes of information that the skilled athlete can provide in order to complete the problem-solving basis of the task. Other studies support this notion in finding more information available to the athlete within observation facilitated performance, (Janelle et al, 2003; Abernathy et al, 1999).

The delivery method, be it by live demonstration or previously videotaped performance, has also been investigated. From this research, no significant differences have been suggested with regard to the delivery of such information, (Bouquet et al, 2007; Feltz et al, 1979; Dubanoski & Parton, 1971; Maccoby & Sheffield, 1961). Recent research however, has shown successful learning of rugby tackling (Kerr et al, 2017), jumping (Benjaminse et al, 2018) and practical rehabilitation techniques (Cooper et al, 2017; Cooper & Higgins, 2017) using video tutelage. A study conducted by Williams (1979) reviewed the opinion of the participants as to which mode of information they preferred. Results were unanimous towards the verbal-live mode of delivery. This shows that even though the performance may not be significantly affected, the preference of human interaction is still important to the observer. A study on surgical techniques supported these preference found by Williams (1979). The results revealed that both live and video-based education showed significant improvements in performance, but were preferred by participants for different personal reasons. Participants showed preference to video when it came to convenience, accessibility, efficiency, and review, whilst preferring the live skill



demonstration regarding knowledge retention, preparedness, and ease of completion.

More recent research has debated video versus live education of surgical tasks. A range of studies has been conducted examining if any differences into the effectiveness of these methods can be identified. Live mentor-based education has been shown to be significantly effective at priming fine motor patterns related to complex surgical techniques (LeBel et al, 2018; Timberlake et al, 2018). Similarly, video tuition has again been shown to create significant improvements in learning surgical techniques (Yeung et al, 2017; Brouwer et al, 2017). Research in this field has attempted to find if one is superior to the other by directly comparing the performance within a randomised controlled study. Results have been consistent in showing that both form of education are successful at educating, and do not differ in effectiveness in comparison to one another (Pilienci et al, 2018; Lwin et al, 2018; Al-jundi et al, 2018).

As studies to date have yet to explore this preference observing continuous, whole body coordination, involving gross movements the current thesis aims at providing an insight into this (aim 4). Furthermore, the thesis directly compares the two within the same controlled study (aim 5), providing insight with greater experimental reliability as in more recent studies (Pilienci et al, 2018; Lwin et al, 2018; Al-jundi et al, 2018).

## **2.5. Design considerations within learning paradigms**

Research has provided coaches and the athletic population with a myriad of studies pertaining to the most effective means to train/educate their athletes. Considering this, the design of such studies must sustain high levels of

reliability and validity to aptly facilitate the development and flexibility of learning. Duration of acquisition and retention test phases are critical for reliable results and should be of suitable duration to confirm the prolonged retention of knowledge that is considered learning.

Glenn Cross (1992) stated that it is the reliance on the capability to understand and retain relative information concerning behaviour, which depicts the performer's ability to learn. It is clear from this statement, that the ability to acquire knowledge is worthless if the ability to retain information is flawed. Information which fails to be retained could be regarded as a failed attempt at learning and merely the possession of short-term knowledge. It is the sustainability of information against all constraining factors that will provide an athlete with the greatest chance for success. Failing to retain the information may provide an athlete with an insufficiently prepared mind to guide a skilled body. This should be considered when evaluating the effectiveness of an applied learning intervention.

#### 2.5.1. Retention test considerations

The rate of acquired knowledge deterioration has been thoroughly researched by Allen & Reber (1980) demonstrating that not only information regarding a novel grammar task can be learnt implicitly, but can also be demonstrated two years after acquisition. Beyond the one year retention phases of Poolton et al, (2007b), this is one of the longest retention periods included in an intervention study demonstrating the need for current research to employ more credible design proceedings.

Research has been conducted in a sporting context using shorter retention periods of four to six months, (Raab et al, 2005), four months (Hodges & Franks, 2001), five to six weeks (Weiss, 2011; Farrow & Abernathy, 2002), two weeks (Orrell, 2006) or more recently seven days (Tzetzis & Lola, 2015). Results from these studies do provide evidence regarding the lasting effects of learning. However, the use of a mere twenty-four hours is a popular length of a retention phase, (Lam et al, 2009a; 2009b; Laguna, 2008; Hayes et al, 2007; Badets et al, 2006; Jannelle et al, 2003; Shea & Wulf, 2001; Hodges, 1999) or most recently Tse et al, (2017a) using a forty-eight-hour window. Retention tests of this length substantially decrease the reliability of their findings. Retention tests are inherently designed to examine the long term effects and have been shown to provide more effective learning when retention testing is conducted one week after acquisition (Roediger III & Karpicke, 2006). Many of these studies employ a sequential day within the acquisition phase, therefore using the same time period as a retention phase. This would show little evidence that the influential effects of other temporary variables at the time of acquisition would have dissolved. This may simply be taken as an extension of the acquisition phase or a post intervention score, and not as a separate chapter within the experimental procedure. Several studies fail to include a retention test, for reasons which are not stated, (e.g. de Melker Worms et al, 2017; Masters et al, 2008; Mullen 2007; Williams et al, 2004; Abernathy & Wood, 2001; Law et al, 2000; Liao & Maxwell et al, 2000; Abernathy et al 1999; Bright & Freedman, 1998; Seger, 1997; Hardy et al, 1996; Masters, 1992; Dienes & Broadbent, 1991; Neill et al, 1990). This is contradictory to the research objective as any information derived from a retention period would provide further understanding of the learning effectiveness. Pivotal studies in

the field of implicit/explicit learning (Masters, 1992), report vital characteristics regarding conscious learning processes, but fail to report whether these effects were lasting. By employing a longer retention period, it will qualify the sustainability of any such learning effects, fulfilling the true objective of didacticism.

### 2.5.2. Acquisition test considerations

The research behind motor learning has included a range of acquisition periods. Some perform a training period of up to four weeks (Janelle, 2003; Liao & Maxwell et al, 2000; Abernathy et al, 1999), whilst others can be as short as seventy-two hours (Lam et al, 2009a), forty-eight hours (Lam et al, 2009b; Hodges et al, 2003; Hodges & Franks, 2002; 2001; 2000) or less than twenty-four hours (Tse et al, 2017a; Price et al, 2009; Liao & Masters, 2001; Neill et al, 1990). The goal of acquisition periods is to provide sufficient time and exposure in order to fairly establish the effectiveness of learning a task (Kirk, 2013). Seger (1997) provided evidence regarding the effectiveness of exposure of acquisition periods. Results showed that explicit learning was significantly facilitated when the acquisition phase was lengthened from twelve blocks compared to shorter periods (two and six blocks). Each block involved a total of one hundred repetitions however, all blocks were conducted within seven days. The increased exposure allowed for increased performance, however both groups showed significant improvements within the seven day window. Using an acquisition of seven days whereby learning occurs consistently and continuously over the week is shown to be effective when advancing learning. It is also important to consider the intensity/ exposure of

the instruction of the learner. Seger (1997) states levels of exposure can have varying influence on learning. Shorter acquisition periods can be employed but only when the intensity/exposure of the learning is maintained.

The crucial issue within acquisition periods focusses on creating a balance between duration and intensity of training (Bompa, 1999). The use of micro-cycles in strength training is similar in length to that of a seven-day acquisition period, involving substantial repetitions of the task, relevant to task difficulty (ACSM, 2017). The phrase '*repetitia mater studiorum est*' meaning 'repetition is the mother of study' demonstrates that by allowing for as many repetitions as possible within acquisition, can only facilitate learning further (Bompa, 1999). By limiting the availability of practicing the task, research may find that the subjects are unable to fully learn the task and could demonstrate poorer performance. The use of short acquisition periods may lead to misdirected assumptions when an explicitly learnt or complex task may be unable to be fully learnt. This will imply inferiority in performance when compared to an implicit task.

The ability to learn new outcome measures declines over the course of healthy ageing (Nassar et al, 2016; Eppinger, et al 2011; Burke & Barnes, 2006). Despite this, Tse et al (2017a) employed a shorter acquisition period of only two days when examining analogy learning of table tennis in older adults, compared to examining skipping technique in children using analogy, and an acquisition period of two weeks (Tse, et al, 2017b). Both studies yielded supporting evidence for the use of analogy education, and the reasoning for either length was not stipulated. Research using short acquisition periods with successful results provide insight into the rate of how quickly learning can

occur. Whilst this is an important finding, using a design of such short acquisition phase can risk a false negative finding as in the case of Williams et al (1994).

Advance cue utilisation research conducted by Williams et al (1994) may have resulted in such an incorrect assumption. Results showed that no differences existed between either group whilst undergoing visual training. They concluded that either form of training is suitable as no significant differences were identified. A single acquisition phase was used lasting a mere forty-five minutes. The skill examined the process of understanding the advance cues demonstrated milliseconds before a required complex full body movement reaction of a tennis serve. This is highly unlikely to have been developed within such a short period of time. Based on this criticism, the results may have shown no differences due to an inability to fully understand the skill and meet its requirements.

Employing a longer acquisition period, may allow for differences to emerge between the training approaches. The current thesis will employ longest potential acquisition periods practically possible, using testing periods similar to that of other research conducted on large movements (Tzetzis & Lola, 2014; Komar et al, 2014; Lam et al, 2009). This will provide the greatest opportunity for learning in accordance with Kirk (2013).

### 2.5.3. Classifying skill level

Another possible explanation for some ambiguity of differences in research focussing on learning effectiveness, can be attributed to the mismatching of the appropriate stage of learning with the implemented task.

There are three stages of learning according to the information-processing approach; the verbal-cognitive, motor and autonomous stage (Fitts & Posner, 1967). The learner progresses through these stages as they become less dependent on extrinsic feedback and become more independent within their individual learning program, (Schmidt & Wrisberg, 2004). Such similar stages have been reported by Gentile (1792) and Fitts & Posner (1967). When focussing on the autonomous stage of learning, experienced participants should be recruited, and the term 'experienced' has been cited when describing the skill level of its participants by several studies, (van der Graaff, et al, 2017; Gray, 2017; Raab et al, 2005; Williams et al, 2004; Weeks & Anderson, 2000; Farrow & Abernathy, 2002; Allen & Reber, 1980). The definition of 'experienced' refers to knowledge of skill which is gained through previous exposure or involvement in educating stimuli, (Kent, 2006). As there is a lack of any reference to time or periodisation within this definition, it leaves the issue of how much experience does one require in order to be 'experienced'. Any answer pertaining to this question can only be vague at best and cast doubt in the ability to match the task complexity with that of the individuals' stage of learning. It would be advantageous to test subjects with no prior experience in the task so that not only a level playing field can be established, but also the determination of the learning stage.

Many studies incorporate learning interventions focussing on using novice participants (Tse et al, 2017a; 2017b; Van Ginneken et al, 2017; Komar et al, 2014; Tzetzis et al, 2014; Lam et al, 2009a; 2009b, Mullen, 2007; Badets et al, 2006; Orrell et al, 2006; Janelle, 2003). This classification can be just as misleading as some classifications are questionable within the literature. Such misleading classifications as "no practice within the past month" (van Ginneken

et al, 2017), twelve months (Bright & Freedman, 1998), previous two weeks' (Law et al, 2000) or three years (Weeks & Anderson, 2000).

Consequently, research must remain longitudinal and persevere to be conducted on various levels of skill, from novice to professional. Learning characteristics can alter as a result of progression (Gentile, 1972). Ideally, the use of participants who have never practiced skill before, such as (Lam et al, 2009a; 2009b) would prove the most effective for learning to begin but may ultimately change as a result of progression. This may impact on the approach taken and is evident within the current thesis. Using an analogy learning strategy with novice participants may lack practicality as the method lacks any means of understanding the actual movement. This understanding is key for progression towards fully controlling and modifying the movement at a later stage of learning.

In the event of classifying experience or skill level, the sport itself will dictate where the line lies between skill levels. The most logical method to draw this conclusion would be to consult professional coaches who understand the needs of the sport. Coaches who are deemed expert, based on their experience, would provide reliable insight based on their understanding (Wiman et al, 2010).

#### 2.5.4. Ecological validity

The environment can significantly influence the development of any learning process. Gibson (1986), suggests an individual is only capable of the performance afforded by the environment. Therefore, any learning will be governed by the environmental context. The Constraints Model (Newell, 1986)



suggests the ability to produce meaningful coordination is dependent on the organism, task and environment. The constraints placed on the individual within a laboratory setting may not necessarily need to be more or less demanding, but merely differ within the applied movement constraints of an ecologically valid environment, to affect behaviour/performance. Thus, the implementation of a field setting will provide a closely related environment for the performance to occur out of testing. This will increase the ecological validity of the testing methodology, and the applicability to the real world. There are various examples within the literature relevant to this thesis that have accomplished this; van der Graaf et al, (2017), Tzetzis & Lola (2014), Komar et al, (2014), Lam et al, (2009a; 2009b), Masters et al (2008,a), (2008b), Ram et al (2007), Williams et al (2004), Farrow & Abernathy (2002), Liao & Masters (2000), Weeks & Anderson (2000), Law et al (2000).

By conducting the intervention within a laboratory, experimental reliability is maintained as variables can be accounted for and controlled more easily. This is highly important as any differences observed provide a pure account by the intervention. This can occur only if the independent variable (s) or other confounding variables are fully maintained. This concept is held in high regard with many studies, (Shane et al, 2008; Laguna, 2008; Vogt & Thomasckle, 2007; Mullen, 2007; Poolton et al, 2007a; 2007b; Orrell et al, 2006; Badets et al, 2006).

In the case studies such as Bouquet et al (2007), the sophistication of the equipment being used requires the apparatus to be used indoors. Research is unable to provide insight into promising new arenas of discovery without laying reliable foundation for the existence of new pathways. This is why studies such as Bouquet et al (2007) should be performed and viewed as the start of such

exploration but not the entire journey. Sport is conducted within a dynamic, unpredictable environment where a performer must learn to behave in all its deformities.

This notion of environmental complexity is compounded when risk is increased (Zuckerman, 2007). High-risk Olympic sports such as skateboarding, BMX and surfing force the performer to exist within a unique environment due to the intense thoughts and emotions that occur as a result of the intense uncertainty of the environment (Way, 2012). The study of learning should attempt to represent and reflect that environment as close as possible for optimal adaptation. Issues such as convenience towards testing protocol should be viewed as secondary, to that of the necessity to provide ecologically valid support to sporting research. It is not the opinion of this review to disregard the importance of experimental reliability, but to accept that any confounding variables which exist within the sporting environment will still continue to exist in both research and application. Educated means can be taken towards the protection of experimental reliability through classic scientific protocols of randomised control groups, whilst still exposing the athlete to the truest environment they will experience; a dynamic, organic, statistically unreliable setting.

The overarching concept of this thesis is to explore the effect of reinvestment in athletes exposed to anxiety due to the nature of their high-risk sports. Throughout this chapter the concept of anxiety has been defined, along with the influential effect on the specific mechanisms underpinning learning. As mentioned in chapter one, there is a growing rate of participation within high-

risk sports along with the number of institutions to support this demand. These institutions are designed to instruct how to perform effectively throughout high-risk sports under such high levels of anxiety.

Anxiety has been shown to have a severe negative effect on performance via aspects on Baddeley's (2000) theoretical working memory model. Although there is some debate as to why, how or even which components of working memory are inhibited, all opinions converge as to the debilitating effect that the pressure of anxiety can debilitate performance.

These effects can occur as a result from reinvesting within one's actions, and can occur in high-risk sporting environments, given that the potential risk is present. This thesis intends to initially examine the differences between reinvestment tendencies between those of high-risk sporting participants and more traditional sports, whereby risk is not a defining characteristic. The concept of risk inherently increases alongside progression within high-risk sports due to heightened complexity at a more advanced stage. By examining the high-risk populous within these progressive stages of performance, it would allow initial preliminary insight into the reinvestment tendencies, indicating a potential contradictory relationship to current autonomous learning theory (i.e. increased consideration of movement with experience).

Following this, the current thesis aims to explore the range of implicit-based learning strategies against explicit learning strategies at each stage of performance. This could provide primary insight into educating the growing rate of participation at high-risk sports institutions (e.g. Camp Woodward) using an ecologically valid approach. These subsequent studies may provide insight for coaching from a practical perspective, examining the effectiveness of live versus video demonstration. Additionally, they attempt to provide incentive

understanding into the application of implicit-based skill acquisition upon complex, whole body movements.

# Chapter 3

## Experimental Study 1

### ***“Reinvestment propensity and sensation seeking tendencies within various skill level in high and low-risk sports”***

The following chapter consists of data collected from a single sample, then presented and exposed to two testing questionnaires from a combined experimental pack. The experimental pack consisted of both the Movement Specific Reinvestment Scale (MSRS) and the fifth version of the Sensation Seeking Scale (SSSV). Due to the nature of the study reported in this chapter and the multiple variables being considered, the subsequent chapter has been written up in two stages to provide greater clarity. The overall aim of the current chapter is to identify and analyse potential differences between high and low-risk sports in both sensation seeking and reinvestment traits. By investigating the differences in sensation seeking trait, this may illustrate a unique characteristic of high-risk sports, known to be linked to a sensitive attentional capacity (Zuckerman, 2014). A systematic review by Goma-i-Freixanet, et al (2012) identified that the sensation seeking tendencies of participants engaged in high-risk sports were higher than low-risk sports, from the thirty-six studies reviewed. To date no research has examined this trait in modernised high-risk sports (e.g. skateboarding, snowboarding etc.) Furthermore, no research has examined any potential differences within high-risk sports regarding learning stage from novice to professional. Way (2012) identifies progression of risk as

a fundamental belief within modernised high-risk sports, as a means of 'constantly pushing boundaries and overcoming them'. As risk is the defining characteristic of these sports, performance at a higher professional level could potentially incur greater risk, influencing differences in the sensation seeking component.

These differences were then investigated further by examining the effects of these traits in relation to the stage of learning. These stages were identified in accordance with Fitts & Posner (1967), and experienced professional coaches currently working within the sports. Firstly, research concerning the behavioural trait known as sensation seeking will be presented, as a means of identifying a differentiating, unique characteristic of high-risk sports.

Following this, research regarding reinvestment is presented to establish potential differences within sporting samples and reinvestment, given the influence of increased sensation seeking and attention hypersensitivity (Zuckerman, 2014).

### **3.1. The role of Sensation Seeking in experimental study 1**

#### **3.1.1. Introduction**

The arena of action sports (skateboarding, snowboarding etc.) is frequently associated with 'adrenaline junkies' who are obsessed with attempting suicidal stunts at great risk (Brown, 2005). Popularity of these sports is significantly increasing with over 40 million participants within the USA, creating a multi-billion dollar industry (Thorpe & Dumont, 2018).

To date, little scientific research has been conducted focussing on high-risk sports. Research from a socio-cultural aspect has revealed sports such as

skateboarding and BMX to come from shared ideologies amongst a unique culture (Brymer & Oades, 2009; Browne, 2005).

Inside this unique culture it has been noted that the approach to new objectives (stimuli) has been received positively, demonstrating a potential linear relationship between high-risk and euphoria, (Davis & Phillips, 2004). This relationship between high-risk and drive to perform, despite fear, potentially distinguishes these athletes from other sport performers. Brymer & Schweitzer (2012) explored reasons for participation in high-risk sports, in order to gain insight into aspects of fear and anxiety using a phenomenological approach. Findings showed that these athletes perform with conscious awareness of fear and anxiety, despite reports of reckless disregard for safety and a pathological need for excitement (Brymer, 2010). High-risk sportsmen performed fully aware of fear, viewing it as a motivator or challenge to overcome for personal development (Kiemle & Lavellee, 2017). This unique perspective may be linked to elements of personality and has been studied in an attempt to create a profile of those who participate in high-risk sports (Barlow et al, 2015; Monasterio et al 2012).

The personality of high-risk sport athletes has been examined in an attempt to create a profile in various ways. Monasterio et al (2012) examined the personality characteristics of BASE jumpers using the Temperament Character Inventory (Cloninger et al, 1994b). The study compared BASE jumpers to age matched control groups of normal population. Results showed that BASE jumpers scored significantly higher in novelty seeking and significantly lower in the character traits Harm Avoidance, Reward Dependence and finally, Self-Transcendence (Monasterio et al, 2012). The findings relating to Harm Avoidance and Novelty Seeking are not surprising given the nature of the

sports. Significantly lower scores on reward dependence suggest an explanation as why these individuals gravitate towards individual sports, given their independence of others (Monasterio et al, 2012). Finally, the low scores within self-transcendence have been associated to pride, impatience and a general struggle to accept failure (Cloninger et al, 1994a). It is these aspects of personality that may encourage these athletes to perform without allowing fear of risk to deter them. This could be argued as an addictive personality associated with the trait sensation seeking (Zuckerman 2007). Lissek et al (2005) found support whereby those scoring high in personality trait Sensation Seeking (Zuckerman, 1978) were found to demonstrate a less aversive motivational system towards unpredictable stimuli when compared to low sensation seekers.

Castanier et al (2010) examined over 300 participants within high-risk sports across multiple personality inventories. The results showed that participants of high-risk sports reported low levels of conscientiousness along with high neuroticism and extroversion. Zuckerman (2007) has linked these specific attributes to the psychological trait known as Sensation Seeking (Zuckerman, 1979).

Zuckerman (1994) defined sensation seeking as the habitual desire for varied, novel and intense sensations and experiences, and the willingness to take physical, social, legal and financial risks for the sake of such experiences. The trait has theoretical roots within optimum level of arousal (OLA) and optimum level of stimulation (OLS). There is a collection of theories ranging from Wundt (1983), Constancy Principle (Breuer & Freud, 1955), the inverted U based theories of arousal put forward by Hebb (1955) and Weinberg & Hunt (1976) and more notably the catastrophe theory (Hardy & Fazey, 1987). The



underlying principle of all these theories refer to an optimal level of arousal or stimulation for a given individual to effectively perform in the best possible way. A similar based theory from a biological basis known as the reticular activation system (RAS) suggests that stimulation of either internal or external nature, activates the nonspecific arousal of the cerebral cortex (Zuckerman, 2007). The RAS system also works within finite boundaries of under or over exposure at what is defined as an optimum level of arousal. The cerebral cortex is understood to work in conjunction with the cerebellum, which is responsible for controlling voluntary movement, balance and posture (Gelb, 2016). By having this area of the brain aroused, it is feasible for this to have an impact on the attentional capacity required to acquire and perform skills. This will be discussed later in this chapter, regarding reinvestment tendencies and in subsequent chapters exploring skill acquisition.

Research has been conducted within high-risk sports from a neurological perspective, whereby those who compete in high-risk mountain climbing and other related sports, were found to have significantly lower levels of a group of neurotransmitters; Monoamine (MAO), (Fowler et al, 1980). Studies have shown a negative relationship between the sensation seeking trait and MAO levels, (Murphy et al, 1977; Schooler et al, 1978; Perris et al, 1980; Shalling et al, 1983). The measurement of MAO has been used to identify the sensation-seeking characteristic and quantify differences between sporting populations, age and gender.

MAO is primarily responsible for behavioural arousal and emotional regulation. With this in mind, performers within high-risk sports can be drawn to the activity as a result of being under-aroused from various other avenues (Wolf et al,

2013; Goma-i-Freixanet et al, 2012; Castanier et al, 2010; Fink et al, 2010).

This suggests there may be a biological basis behind the sensation-seeking trait but due to the invasive nature of this testing, a more practical method was introduced to examine this trait indirectly through questionnaires (Zuckerman, 2014).

Another means of measuring the sensation-seeking trait is through a questionnaire known as the Sensation Seeking scale V developed by Zuckerman et al (1978). It is comprised of four main components; Thrill and Adventure Seeking (TAS), defined as the desire to engage in physical activities that provide unusual sensations and experiences. Experience Seeking (ES), understood as seeking sensation and new experiences via the mind and sense through a nonconforming general lifestyle. Boredom Susceptibility (BS), which is the aversion to any kind of monotonous conditions and the restlessness when confined to such conditions. Disinhibition (Dis), referring to seeking sensation through a hedonistic lifestyle, wild parties, sexual variety and drinking to disinhibit (Zuckerman, 2007). These individual sub-scales yield a respective score along with a combined total score for trait; Sensation Seeking (SSSV). The subscales have been shown to have high internal reliability for subscales (TAS, 0.82; ES, 0.67; Dis, 0.78; BS, 0.65) alongside high test-retest reliability ( $r=0.94$ ) and internal reliability ( $r=0.86$ ) for total score (Zuckerman et al, 1978)

Research has been undertaken to establish if sensation seeking is a stable genetic trait or influenced through social exposure or environmental interaction. Sensation seeking has been shown to increase during childhood, peak in early adulthood followed by a steady decrease as we get older (Zuckerman, 2007). Lynne-Landsman et al (2011) reported that those who were defined as

high/medium/low sensation seekers remained stable throughout 11 to 13 year old school children. Further research supports the stability of the trait whereby biological twins have been assessed within both shared (Fulker et al, 1980) and separated non-shared environments (Hur & Bouchard, 1997) reporting similar high sensation seeking trait within both twins. Contrary to these findings, Boomsma et al (1999) showed that separated twins from different religious backgrounds showed significantly different levels of sensation seeking despite having shared genetics. This implies that environmental interaction may influence sensation-seeking tendencies.

To date no research has examined the effect of sensation seeking across a spectrum of development within sporting populations. As research has shown the possibility for environmental influence, it is important that differences between high and low-risk sports within these populations be investigated. It is feasible that exposure to such a high-risk sport given the addictive personality, that this trait could be nurtured and be developed further. In accordance with Fitts & Posner (1967), learning progresses from a cognitive (novice) stage through to an autonomous (expert) stage of performance. Throughout this progression the movements that are performed require a higher degree of skill in order to achieve success. Within high-risk sports the risk of serious injury is directly related to failure to perform successfully, therefore increasing the element or risk due to the higher complexity of the skills as progression occurs. Participants of high-risk sports who have progressed from novice through to expert stages may hypothetically differ in sensation seeking tendencies based on the inherent level of risk involved. Conversely, these differences in

performance may only occur due to potential genetically stable traits possessed within the different individuals.

Research has been conducted within a variety of sporting populations using the Sensation Seeking Scales. Zuckerman (1994) classified sports as either low, medium or high based on the risk factor involved in participating. Sports with little chance of serious injury were classified as low-risk (e.g. tennis) whilst sports with a high probability of injury only where the environment is static and limited (e.g. most team sports) were classified as medium-risk. High-risk sports were categorised based on a high probability of serious injury or death as a consequence of practicing. Research conducted on low-risk (tennis, golf, physical activity, etc) sporting samples found significantly higher scores on Thrill & Adventure Seeking, Disinhibition and Total sensation seeking score when compared to a non-sporting control group (De Moor et al, 2006; Breivik, 1996; Slinger & Rudestam, 1997; Schroth, 1995; Hartman & Rawson, 1992; Gundersheim, 1987).

Medium-risk sporting populations (rugby, climbing, karate, diving etc.) reported significantly higher scores when compared to a control sample (Hinton-Bayre & Hanrahan, 1999; Hughes et al, 2003; Davis & Mogk, 1994; Rossi & Cereatti, 1993; Potgieter & Bisscoff, 1990), whilst other research conducted with similar samples found no significant differences (Canton & Mayor, 1994; Davis & Mogk, 1994).

High-risk sporting populations (rafting, parachuting, surfing, snowboarding, skiing) when compared to low-risk controls have scored significantly higher on Thrill & Adventure Seeking and Experience Seeking sub-scales and total sensation seeking (Cohen et al, 2018; Klinar et al, 2017; Rhea & Martin, 2010;

Cazenave et al, 2010; Diehm & Armatas, 2004; Goma-i-Freixanet, 2001).

Scores within the sub-scales Boredom Susceptibility and Disinhibition are inconsistent throughout research in high-risk sports.

Contemporary research has examined the sensation seeking trait within modern day high-risk sports, otherwise referred to as action sports or as extreme sports by Agilonu et al (2017). The research examined 101 athletes from various high-risk sport representing “extreme sports”. The results showed meaningful relationships between both risk taking and sensation seeking attributes examined. This was explained as a development of a common personality profile encompassing risk taking behaviour, excitement seeking, focus of control, self-efficacy, perceived benefit and emotional imbalance (Baretta et al, 2017; Leea & Tsengb, 2015; Merritt & Tharp, 2013; Rolison & Scherman, 2003). This risky behaviour and physical consequences have been shown to be prominent within high-risk sports of more traditional nature. Beidler et al (2017) has shown a significant correlation between sensation seeking trait and sport related concussion (SRC) within collegiate student-athletes engaged in (American) football.

Minimal research has been conducted on the nature of professional and amateur comparisons, however Cazenave et al, 2010 found that sportswomen in high-risk sports for leisure purposes scored significantly higher on total sensation seeking score but showed no significant differences within individual sub-scales when compared to professional high-risk sportswomen.

The aim of the first part of this chapter is to examine the potential differences within sensation seeking propensity within different sporting populations. To date, no research has investigated modern high-risk sports

compared to low-risk controls either as a whole, or at each of the possible stages of learning progression. Minimal research has examined the differences between professional and amateur status and the effects on sensation seeking, with no research comparing each status across differing levels of risk. Based on the extant research it is hypothesised that those participating in high-risk sports will score significantly higher than low-risk counterparts as this is a unique characteristic of this sporting culture. Although this has been shown previously, it is yet to be established within modern day high-risk Olympic sports (e.g. snowboarding, skateboarding etc.).

### 3.1.2. Methodology

#### *3.1.2.1. Participants*

Participants were recruited on a voluntary basis using a convenience sampling technique. A total of 613 participants who were currently involved within high-risk sports (skateboarding [n=501], snowboarding [n=48], BMX [n=64]) comprised the high-risk sports sample. 248 participants formed the low-risk sporting sample (golf [n=116], swimming [n=73], discus [n=37], tennis [n=22]) (see Table 1 for details). All participants involved were remained naive to the research hypothesis, until the end of final testing phase. Ethical clearance was authorised by the Teesside University research ethics committee. The statistical package utilised (SPSS v.22) ensured protection against the effects of unequal sample sizes (Tabachnik & Fidell, 2007; Brace et al. 2009).

Group	N	Age (Years)	Experience (months)
High-risk sports (HR)	613	22.1 ± 5.64	86.45 ± 78.99
Low-risk sports (LR)	248	20.5 ± 2.50	69.17 ± 46.87
High-risk sports Novice (HR Nov)	114	17.32 ± 1.12	8.35 ± 2.84
Low-risk sports Novice (LR Nov)	45	17.93 ± 0.86	9.89 ± 1.43
High-risk sports Intermediate (HR Inter)	220	18.69 ± 1.81	39.29 ± 12.99
Low-risk sports Intermediate (LR Inter)	72	19.94 ± 1.41	41.89 ± 9.03
High-risk sports Expert (HR Exp)	279	26.75 ± 5.18	155.54 ± 67.45
Low-risk sports Expert (LR Exp)	131	21.69 ± 2.58	104.52 ± 35.22
High-risk sports Amateur (HR Am)	508	20.72 ± 4.56	66.61 ± 63.69
Low-risk sports Amateur (LR Am)	225	20.11 ± 2.08	60.25 ± 36.94
High-risk sports Professional (HR Pro)	105	28.77 ± 5.66	182.4 ± 75.73
Low-risk sports Professional (LR Pro)	23	24.30 ± 3.05	156.35 ± 44.88

*Table 1. Sample sizes post-categorisation based on variables; sport, experience and status (Experimental study 1)*

### 3.1.2.2. Procedure

A selection of retail stores catering for high-risk sport across the United Kingdom were invited to participate by distributing a collection of research packs to the potential sample. All stores were informed of the nature of the research and the procedures to be undertaken. A total of six stores indicated a willingness to participate. Additionally, participants were recruited through a network of professional sponsors, which provided additional access to professional athletes. The low-risk sporting sample was acquired in an identical fashion from a collection of sports clubs, based again on access and willingness to participate.

The research pack (see appendix 1-3) consisted of an information sheet explaining a brief outline of the study, a consent form with participant details (e.g. age, experience level and time involved within their chosen sport) and a copy of the Sensation Seeking Scale V (Zuckerman 1978). Upon completion of the packet, the information was placed into a sealed envelope and was collected at a later date by the leading researcher. All participants were naive to the research hypothesis until after completion of the questionnaires, where

they were then provided with a debrief sheet complete with contact information for further enquiries.

Responses were categorised according to two separate variables; sports experience and performance status. Experience was used to categorise groups by consulting five professional coaches/athletes whereby it was agreed as to what extent length of participation would classify the stage of learning. A focus group methodology in accordance with Krueger & Casey (2009), was used to define the chosen categories. These individuals have competed at the international stage of their sport and are presently qualified coaches within the respective national governing body. The coaches were asked to identify their expectations of skill level of a novice, intermediate and expert performer, give their length of participation in the sport. This resulted in three ability-based categories; Novice ( $\leq 12$  months), Intermediate ( $\leq 60$  months) and Expert ( $> 60$  months). Sample sizes are shown in Table 1. It is recognised that quantity of practice does not solely dictate the quality of learning. These categories were agreed upon based on the coach's opinions of the level of movement control and coordination required for the performance of which they generally witnessed given those exposure rates throughout their professional career. Secondly, the responses were divided based on the current playing status of either amateur or professional (see table 1). Professional status was classified on the basis that sport performance was the chosen profession of the participant.



### 3.1.2.3. Measures

The total score of the Sensation Seeking Scale V (SSSV) was used to quantify sensation seeking. Subsequent analysis was conducted using the four separate sub-scales; Thrill & Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS), and Disinhibition (Dis).

### 3.1.3. Results

#### 3.1.3.1. High-risk Sports vs. Low-risk Sports

All data were screened to ensure normality. Bonferroni adjustments were applied where applicable on post-hoc testing. A preliminary analysis was conducted classifying the data by sporting type; high-risk sports (HR) or low-risk sports (LR). One-way Multivariate analysis of variance (MANOVA), revealed a significant difference between sporting types on all four sub-scales; Thrill & Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS), and Disinhibition (Dis), [ $F(6,854)=981.3, p<0.001$ ; Wilks Lambda=0.127; partial  $\eta^2=0.873$ ].

Post hoc independent samples t-testing confirmed that High-risk Sports (HR) scored significantly higher than Low-risk Sports (LR) on all dependent variables: TAS [ $t=52.425, df=498.996, p<0.001$ ], ES [ $t=52.921, df=489.457, p<0.001$ ], BS [ $t=53.492, df=319.504, p<0.001$ ], Dis [ $t=12.009, df=707.742, p<0.001$ ] and SSSV [ $t=61.976, df=525.891, p<0.001$ ].

Lastly, independent t-tests revealed that the High-risk sports group were significantly older than the General sports group ( $t=5.764, df=852.639, p<0.001$ ).

### 3.1.3.2. 'Experience' and Sensation Seeking

The data when classified by 'experience' level yielded six groups; High-risk Sports Novice (HR Nov), High-risk Sports Intermediate (HR Inter), High-risk Sports Expert (HR Exp), Low-risk Sports Novice (LR Nov), General Sports Intermediate (LR Inter) and Low-risk Sports Expert (LR Exp).

One-way ANOVA showed significant differences between groups regarding all dependent variables examined; SSSV [ $F(5,860)=1144$ ;  $p<0.001$ ; partial  $\eta^2=0.87$ ]; TAS, [ $F(5,860)=1019$ ;  $p<0.001$ ; partial  $\eta^2=0.856$ ]; ES, [ $F(5,860)=1034$ ;  $p<0.001$ ; partial  $\eta^2=0.858$ ]; BS, [ $F(5,860)=1404$ ;  $p<0.001$ ; partial  $\eta^2=0.891$ ]; and Dis, [ $F(5,860)=21.09$ ;  $p<0.001$ ; partial  $\eta^2=0.11$ ]. Post-hoc analyses confirmed that High-risk sport groups scored significantly higher than their Low-risk group counterpart on all variables including Sensation Seeking Total Score (SSSV) (see Figure 1) and all four sub-scales (see Figure 2).

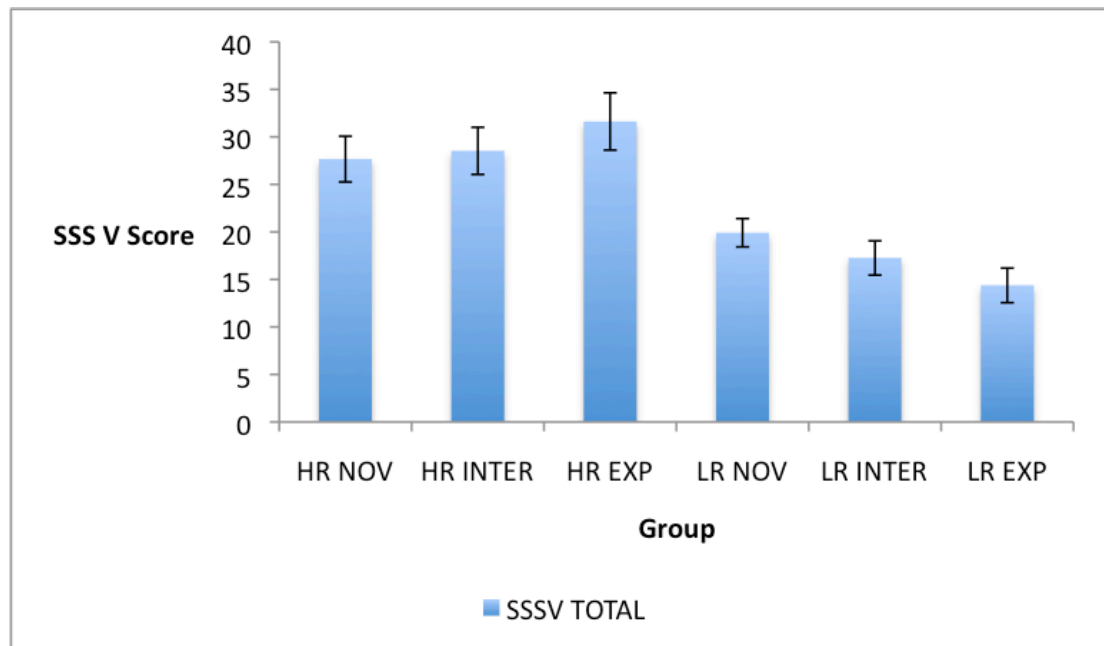


Figure 1. Mean total score of Sensation Seeking Scale V (SSSV) (Zuckerman., 1979) for all 'experience' groups; High-risk Novice (HR NOV), High-risk Intermediate (HR INTER), High-risk Expert (HR EXP), Low-risk Novice (LR NOV), Low-risk Intermediate (LR INTER), Low-risk Expert (LR EXP) in study 1.

Post-hoc analyses showed High-risk sport groups scored significantly higher at each stage of progression from novice to intermediate through to expert on variables SSSV (see Figure 1), TAS and ES (see Figure 2). Low-risk sport groups scores reversed this trend reporting significantly lower scores from novice through to expert on variables SSSV (see Figure 1), TAS, ES and BS (see Figure 2). No significant differences were found throughout progression of either stage for the variable Dis.

One-way analysis of variance (ANOVA) revealed significant differences within the groups for age [ $F(5,861)=222.03; p<0.001$ , partial  $\eta^2=0.565$ ]. Post-hoc analyses indicate that High-risk Novice and Intermediate performers were significantly younger than their General sports counterpart, whilst High-risk Expert was found to be significantly older compared to Low-risk Expert.

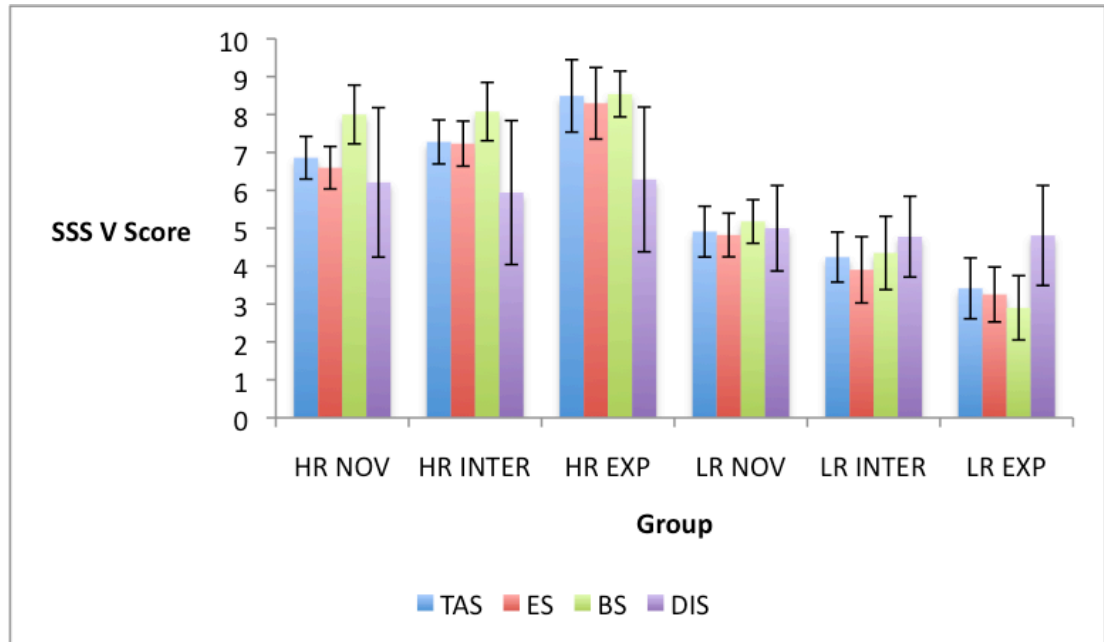


Figure 2. Mean score for sub-scales Thrill & Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS) and Disinhibition (Dis) for all 'experience' groups; High-risk Novice (HR NOV), High-risk Intermediate (HR INTER), High-risk Expert (HR EXP), Low-risk Novice (LR NOV), Low-risk Intermediate (LR INTER), Low-risk Expert (LR EXP) in study 1.

### 3.1.3.3. 'Status' and Sensation Seeking

Finally, the data was classified by '*status*' yielding four groups; High-risk sports Amateur (HR Am), High-risk sports Professional (HR Pro), Low-risk sports Amateur (LR Am) and Low-risk sports Professional (LR Pro).

MANOVA confirmed a significant difference within the four sub-scales TAS, ES, BS, and Dis [ $F(18,2410)=239.55$ ;  $p<0.001$ ; Wilks Lambda=0.055; partial  $\eta^2=0.62$ ]. Post-hoc ANOVA showed a significant difference for each of the four sub-scales; TAS [ $F(3,861)=1437$ ,  $p<0.001$ ; partial  $\eta^2=0.834$ ], ES [ $F(3,861)=1576$ ,  $p<0.001$ ; partial  $\eta^2=0.847$ ], BS [ $F(3,861)=1569$ ,  $p<0.001$ ; partial  $\eta^2=0.846$ ] and Dis [ $F(3,861)=36.689$ ,  $p<0.001$ ; partial  $\eta^2=0.114$ ]. A separate post-hoc One-way ANOVA revealed significant differences within the total Sensation Seeking score (SSSV) [ $F(3,861)=1670$ ,  $p<0.001$ ; partial  $\eta^2=0.854$ ]. The scores for each group when divided based on professional or amateur stats within their chosen sport are shown for total Sensation Seeking score (Figure 3) and subsequent sub-scales (Figure 4).

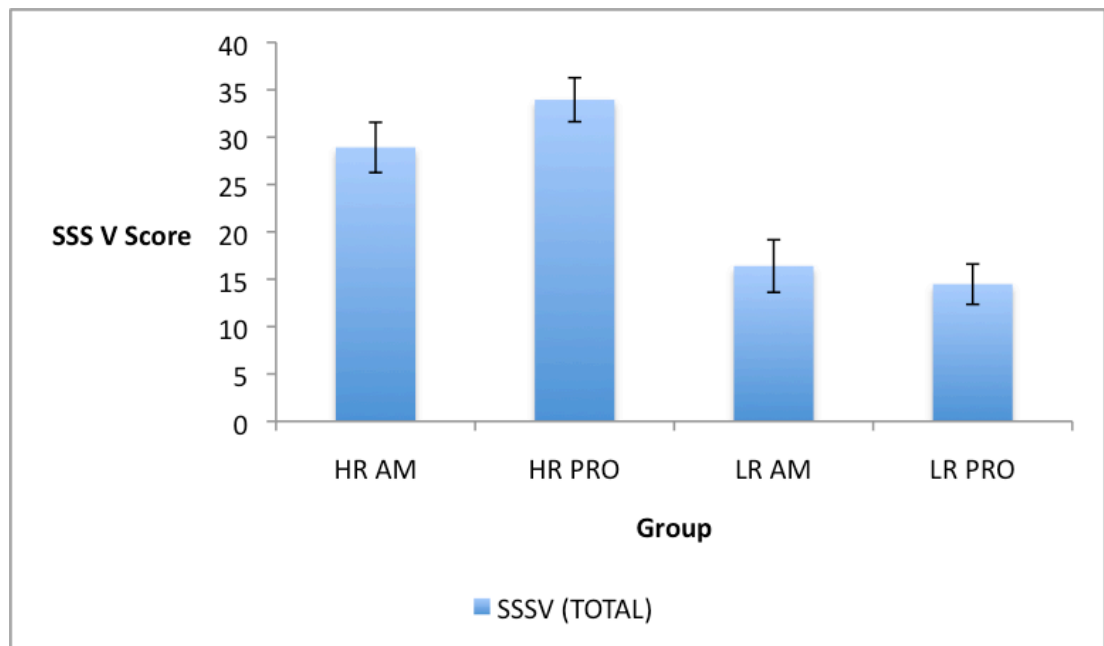


Figure 3. Mean total score for Sensation Seeking Scale V (SSSV) (Zuckerman, 1978) for all 'status' groups; High-risk Amateur (HR AM), High-risk Professional (HR PRO), Low-risk Amateur (LR AM), Low-risk Professional (LR PRO) in study 1.

Those participating in High-risk sports scored significantly higher on all variables, when compared to their respective professional or amateur counterpart. Participants categorised as professional within High-risk sports scored significantly higher than High-risk sports Amateurs on all variables tested. This trend was not demonstrated for Low-risk sport groups, as Low-risk sports Professionals scored significantly lower on TAS and SSSV when compared to Low-risk sports Amateurs. No significant differences were found for any other variables tested.

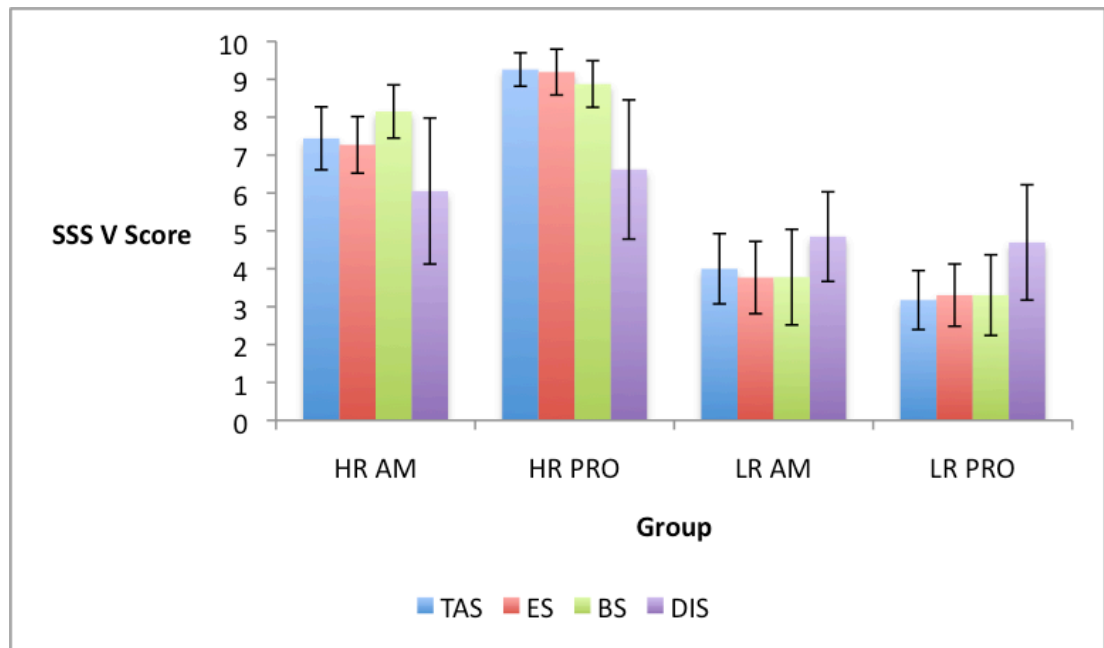


Figure 4. Mean score for sub-scales: Thrill & Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS) and Disinhibition (Dis) for all 'status' groups; High-risk Amateur (HR AM), High-risk Professional (HR PRO), Low-risk Amateur (LR AM), Low-risk Professional (LR PRO) in study 1.

One-way ANOVA confirmed significant differences between groups regarding age, [ $F(3,861)=122.695; p<0.001; \text{partial } \eta^2=0.3$ ]. Post hoc analyses reveal that professional groups were significantly older than amateur counterparts. No significant differences were found between amateur groups (LR vs HR), however High-risk sport Professionals were found to be significantly older than Low-risk sport Professionals.

#### 3.1.4. Discussion

The data supports the hypothesis that those participating in high-risk sports would score significantly higher on all aspects of the sensation seeking trait measured, when compared to a sample of low-risk sports. This result was echoed regarding all aspects of sensation seeking including Thrill & Adventure

Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS) and Disinhibition (Dis).

When examining the differences between professional and amateur performers, High-risk sports professionals scored significantly higher compared to their respective amateur performers. The reverse was found within low-risk sports as professionals scored significantly lower on Thrill & Adventure Seeking (TAS) sub-scale and Total sensation seeking score, with no significant differences on any other sub-scales.

Regarding experience, high-risk sports performers scored significantly higher throughout each stage of progression from novice to expert, on sub-scales Thrill & Adventure Seeking (TAS) and Experience Seeking (ES), along with Total sensation seeking score. Contradictory to this, low-risk sports scored significantly lower on these variables during each stage of progression. No significant differences were found throughout progression for variables Boredom Susceptibility (BS) and Disinhibition (Dis) in either sporting sample. When comparing relative counterpart groups (novice for novice etc.), the data shows that high-risk sports performers score significantly higher on all variables against their low-risk counterpart.

Overall the findings are consistent with previous research showing individuals engaged in high-risk sports elicit significantly greater sensation seeking tendencies represented by the sensation seeking trait (Cohen et al, 2018; Klinar et al, 2017; Rhea & Martin, 2010; Cazenave et al, 2010; Diehm & Armatas, 2004; Goma-i-Freixanet, 2001).

The current study confirms that individuals with strong sensation tendencies tend to participate in high-risk sports, such as modern Action Sports (e.g.

skateboarding, snowboarding etc.) despite stage of learning, or playing status. The inherent risk factor involved with participating in such sports, supports the notions of Zuckerman (2007). Furthermore, those at a higher skill level appear to have greater sensation seeking tendencies compared to a more novice stage of participation. This could be explained by the greater inherent risk involved when performing highly complex movements, demanding greater skill to avoid failure. Participation at an expert or even further professional status, requires performance at greater speeds, heights and distances whilst maintaining superior skills in balance and coordination. Failure to maintain such expectations of skill at the given environmental demands could result in serious, if not fatal consequences. This aspect of risk could explain why significantly higher scores were obtained from high-risk sporting groups in the Thrill & Adventure Seeking (TAS) and Experience Seeking (ES) sub-scales particularly. These two sub-scales are specifically associated with physical activities which do not conform to general norms within society or nature (Zuckerman, 2007). By participating under increasingly dangerous circumstances, it allows the individuals to feel greater sensations. Goma-i-Freixanet (2004) found similar findings whereby subjects scored highly on TAS and ES scales but not Dis or BS sub-scales. This can be attributed due to Disinhibition scores being associated within impulsivity (Zuckerman, 2007).

Although high-risk sport performers take risks, the goal is still to succeed and therefore requires planning and consideration regarding movement and performance. Diehm & Armatas (2004) found support for this planning regarding the Boredom Susceptibility (BS) sub-scale. Within this study although high-risk sports participants were significantly different from general lower risk sporting counterparts in TAS, ES and total score, they failed to be



significantly different from one another at any stage of progression or playing status. Diehm & Armatas (2004) contrastingly didn't find any difference in Boredom Susceptibility between golfers (low-risk) and surfers (high-risk) but they attributed this lack of a difference to surfers having developed patience when waiting for opportune waves to surf. This can be applied to action sports as a whole, based on the nature of performing action sports. When participating in action sports, athletes perform in shared facilities, where it is too dangerous for equipment to be used for multiple people at once (Brown, 2005). Therefore, action sportsmen develop patience in order to practice, along with the notion that performing specific skills will take multiple attempts with a pragmatic approach (Davis & Phillips, 2004).

The current study supports research pertaining to low-risk sports. Zuckerman (2007) states that as age increases the sensation seeking trait decreases. The data shows a significant decrease in sensation seeking within General sports as progression from novice to expert and amateur to professional. In each of these cases the groups were significantly older in comparison accounting for the potential differences in sensation seeking. The results are contradictory, when examining age and sensation seeking in high-risk sports. When comparing professionals to amateurs, and throughout progression from novice to expert, each group was significantly older yet scored significantly higher on elements of sensation seeking. The trait remains stable exhibiting high levels of sensation seeking despite becoming significantly older within high-risk sporting samples.

### 3.1.5. Summary

The results of the study confirm Zuckerman (2007) in that participants in modern day high-risk sports demonstrate similar sensation seeking tendencies to other high-risk sporting populations. They also report significantly stronger sensation seeking trait when compared to low-risk sporting matches. The inherent element of risk allows sensation-seeking individuals an avenue to experience heightened sensations (Diehm & Armatas, 2004). It is unclear from this study as to why those who participate in action sports at a further level of expert or professional level. Although the current study demonstrates a significant increase in sensation seeking as progression into higher risking environments, it does not prove causality. Exposure to the high-risk environment could cause an individual to further nurture their sensation seeking tendencies, or only those with naturally high sensation seeking traits may be able to progress to an expert or professional stage. Future research should aim to resolve this by using longitudinal research designs to clarify if this change in sensation seeking trait within high-risk sports is environmental or genetic.

A significant finding of data from this first aspect of this study has been the evidence supporting modern day high-risk sports exhibiting unique characteristics in comparison to traditional sports of lower risk. The differences shown in sensation seeking impact the possibility of over-arousal of this sporting culture in comparison to low-risk sports. This lends support to research suggesting this form of sport exists within a unique culture or classification, (Kiemle & Lavallee, 2017; Brymer & Schweitzer, 2017; 2013; Way, 2012; Browne, 2005). Given the impact of sensation seeking on optimal

level of arousal and therefore attention or focus, this may also impact skill acquisition.

Acquisition of movement patterns to perform successfully are dependent on attentional constraints. Given that the cerebral cortex is impacted by sensation seeking (Zuckerman, 2007), and shares functional aspects of the brain responsible for movement coordination (Gelb, 2016), this could inherently impact skill acquisition within high-risk sports. The next section of the chapter focussed on examining the attentional focus specifically regarding movement production (reinvestment) of these athletes compared to low-risk sporting performers. By examining this propensity, it will highlight any potential for further study into learning interventions concerning risk and skill acquisition. This data was obtained via the same sporting sample of participants displayed earlier in this chapter.

### **3.2. The role of Reinvestment in experimental study 1**

#### **3.2.1. Introduction**

Action sports (e.g. skateboarding, BMX, snowboarding, surfing, etc) are frequently associated with a high-risk possibility of severe physical harm. Action sports have been defined as activities perceived as being inherently dangerous and/or physically hazardous, involving intense stunts and emotions, (Way, 2012). This collection of sports has slowly become more acknowledged within society as evidenced by since being incorporated into the Olympics, the creation of their own international championships (X Games, Street League Skateboarding), along with various advancements in marketing such as computer games, advertisements, etc. (Browne, 2005).

It is estimated there are around 14 million skateboarding athletes worldwide (Thorpe & Dumont, 2018) and around 86 million individuals participating in extreme sports (Ostrowski, 2002) cementing this unique category of sports into a billion-dollar industry (Browne, 2005). This has led to the development of specific training camps across the United States (e.g. Camp Woodward, Pennsylvania) and United Kingdom (e.g. Camp WESC, Hull). These training facilities generally coach athletes in accordance with primary theories of motor learning such as the Multi Stage Learning Theory (Fitts & Posner, 1967). This theory proposes that learning can be categorised into three stages: Cognitive, Associative and Autonomous. Transcending throughout the stages, focus becomes less explicit at a conscious level, finally resulting in an automatic sense and becoming second nature with little or no conscious thought in the highest stage.

To date, comparatively little research has been conducted focussing specifically on how learning in high-risk sports occurs; however, research from a socio-cultural aspect has revealed sports such as skateboarding and BMX come from shared ideologies amongst a unique culture (Browne, 2005). This unique culture exists within the foundation of performing under extreme emotion, anxiety, and threat (Way, 2010). Brymer & Schweitzer (2012) explored the understanding of fear and anxiety within high-risk sports from a phenomenological perspective. They showed that these individuals are fully aware of the danger involved and the urgency to perform successfully to remain safe. It is the element of severe risk that separates high-risk sports from other sporting activities (e.g. soccer), as there is greater chance of serious personal injury exposing athletes to high levels of stress.

Stress has been shown to be ineffective at disrupting performance when learning occurs via unconscious means. Learning can occur using knowledge acquired implicitly and/or explicitly. Reber (1993) defined explicit knowledge of a skill as rule-based information, available to consciousness and therefore verbalisable. In contrast, implicit learning involves acquiring information independently of conscious awareness. Research has shown that performance of an unconscious nature is more beneficial for stressful performance environments from a range of psychological, biomechanical and psychological perspectives (Poolton et al, 2007a; Gucciardi & Dimmock, 2008; Masters et al, 2008a; Masters et al, 2008b; Lam et al, 2009a; 2009b; Kinrade et al, 2010a). The theoretical root of this is based on the attentional constraints placed on the working memory model (Baddeley & Hitch, 1974) outlined in the previous chapter (see pp 10).

Working memory is an assumed temporary storage system that defines the capacity for complex thought and subsequent action, (Baddeley, 2007). It is comprised of an attentional control system known as the central executive, feeding on stimuli from two sub storage systems (phonological loop and visuospatial sketchpad) to attend and relay to the long term memory store. Working memory also acts as a gateway for the long term memory store to reload previous experiences in order to allow appropriate decisions to be made based on current information being interpreted from the environment, (Baddeley, 2007). This information can then be used to decide what action to take through a decision-making process known as “reinvestment”.

The term 'reinvestment' is defined as the manipulation of conscious, explicit, rule-based knowledge from working memory, to control the mechanics of movement during skill execution, (Masters, 1992). Reinvestment theory, originally proposed by Masters (1992), suggests that reinvesting within movement can disrupt motor production through conscious control using declarative (conscious) knowledge. Subjects who are exposed to stress can instinctively reinvest depending on the emotional strength of this exposure. Reinvestment in sports has been measured using a number of scales. Masters et al (1993) developed the original scale comprising of twenty items as a result of combining specific questions from the Emotional Control Questionnaire (Roger & Nesshoever, 1987) and the Cognitive Failures Questionnaire (Broadbent et al, 1982). The scale showed evidence of high internal reliability (coefficient alpha = 0.80), and high test-retest reliability ( $r = 0.74$ ) during the original assessment of psychometric properties. One criticism of the scale is the lack of face validity, resulting in the development of other scales designed with a specific focus on where reinvestment is directed. The Movement-Specific Reinvestment Scale (Masters et al, 2005) consists of ten items scored on a six point Likert scale. It measures reinvestment from two perspectives yielding a total score and two separate sub-scales. Firstly, by the attention considered towards the mechanics of the movement, represented by the Conscious Motor Processing sub-scale (CMP). Secondly, by the attention reinvested concerning how the movement is produced visually. This is represented by the Movement Self-Consciousness sub-scale (MS-C). Kinrade et al (2010b) developed the most recent modified version of the scale, known as the Decision-Specific Reinvestment Scale. This consists of a total of thirteen items encompassing two factors regarding the conscious monitoring of making

a decision (*Decision Reinvestment*) and the focus of negative evaluations of previous poor decisions (*Decision Rumination*) (Kinrade et al, 2010). The scale showed high correlation ( $r = 0.74$ ) when compared with coaches' ratings of the same individuals' propensity to suffer under pressure.

Research to date has focussed on using such scales to measure reinvestment and assessing the impact of stress on performance during activities such as golf putting and basketball (Malhotra et al, 2015; Kinrade et al, 2015; 2010b; Gucciardi & Dimmock, 2008; Masters et al, 2008a; Masters et al, 2008; Poolton et al, 2007a; Maxwell et al, 2006; Masters 1992). Based on the relatively closed nature of environmental predictability that exists within high-risk sports, many of the decisions have been made prior to participation. Specific tricks or routines have been developed and decided upon before the performer begins (Way, 2010). It is understandable that the controlling movements determine how successful the movement is performed, therefore minimising the physical risk concerned with failure. This emphasis on controlling movements may possibly influence the extent of subsequent reinvestment. It was for this reason that the current study selected the Movement-Specific Reinvestment Scale (Masters et al, 2005) over other skills relating to reinvestment propensity.

There is a lacuna in the literature regarding reinvestment propensity in relation to baseline reinvestment tendencies of the high-risk sporting population as a whole. Furthermore, no research has been conducted using fear of personal injury as a valid stressor calculated to induce reinvestment in sport. Research has been conducted in the field of neuro-rehabilitation, where

increased levels of reinvestment have affected motor production because of fear of personal injury. For example, Wong et al (2008) found that victims who encountered falls as a result of impaired movement, reinvested significantly more in their gait than those who had suffered from less severe falls. Logistic regression revealed a significant association between the Movement Specific Reinvestment score and the 'faller or no faller' status. Wong et al, (2008) proposed that the fear of physical harm resulted in an instinctive propensity to reinvest within their movement. Similar findings have been reported with patients suffering impaired neuromuscular control as a result of stroke (Denneman et al, 2018; Kal et al, 2015; Orrell et al, 2002) and Parkinson's disease (Masters et al, 2007). Research has suggested that impaired motor production has resulted as an influence of increased reinvestment, labelling this phenomenon 'cautious gait' (Nutt, 2001).

Fear of personal injury (fall) has caused participants to reinvest more in order to control the movement to avoid injury. This increase in reinvestment has then resulted in greater chance of failure to perform at the requisite level. Research has suggested that fall risk is greatly increased for individuals who direct attention consciously to their own movements (Kal et al, 2016; Young et al, 2016; Wulf, 2013; Chiviawsky et al, 2010; Wong et al, 2008). Additionally, it has been suggested that this risk could be reduced if the movements were allowed to become more automated, requiring less conscious/active attentional control (Kal et al, 2016; Young et al, 2016; Wulf, 2013; Chiviawsky et al, 2010). Although this research supports the association of reinvestment and fear of risk, a recent study conducted by de Melker Worms et al (2017) found no significant differences between falling and reinvestment. This study was



conducted on older, healthy individuals unlike research by Orrell et al (2002) or Masters et al (2007). de Melker Worms et al (2017) attribute the absence of association due to the walking task lacking motivation towards the environmental effect. The risk factor could be emphasised greater in patients who have suffered falls and possibly more aware of an increased risk of falling. Skills that are potentially considered automatic by the subjects, such as the walking task for healthy individuals (de Melker Worms et al, 2017) may not be regarded as risky when compared to subjects with a conscious past history of extraneous factors such as a stroke. Considering such a factor, it could consistently impact the everyday environment of individuals (Danneman et al, 2018; Kal et al, 2015; Masters et al, 2007; Orrell et al, 2002). This environmental change could be recreated in high-risk sporting environments. Participating in events that are purposefully high in risk, may constitute as an environmental effect. The risk factor is specifically inherent to participation in high-risk sports. The high-risk aspect emphasises the success of executing skills within the given risky environmental context attributing to understandably heightened emotions. This can then influence a participant's propensity to reinvest within their movements to execute the skill correctly.

Williams et al (1997) suggest extreme emotion (including anxiety or fear) can cause a tendency for patients to bias their focal attention towards the stimulus of fear. This bias is primarily involuntary and can be triggered by external environmental cues, or internally as a result of previous thoughts and memories be it positive (e.g. desire) or negative (e.g. anxiety). The Processing Efficiency Theory (Eysenck, 1992) otherwise known as the 'worry' hypothesis, suggests that anxiety can preoccupy working memory with focusing attention

on 'what may go wrong' leaving less capacity to focus on performance (Eysenck & Calvo, 1992). Similarly, positive emotion such as desire outlined in the Elaborated Intrusion Theory (Kavanaugh, 2005) is claimed to result in appetitive targets automatically triggering intrusive thoughts for attention. This in turn, could have a comparable effect on the working memory as negative emotions proposed by Eysenck (1992). With increased emotional stress it is feasible for greater emphasis to be focalised on the performance in an attempt to minimise or satisfy such emotional thoughts. A study conducted by Kiemle-Gabbay & Lavalley (2017) explored coping strategies within elite snowboarding as a means of enduring the stressors of such high-risk performance. Results showed, using thematic analysis of interviews that a focus on actions and control management are shown to be most popular amongst these performers (Kiemle-Gabbay & Lavalley, 2017).

As mentioned previously, training programs employ the use of learning theories such as the Multi Stage Learning theory (Fitts & Posner, 1967). This theory states that as a performer progresses from a cognitive to autonomous stage of learning, the use of declarative knowledge and reinvestment is lessened. Therefore the focus on the self and their actions are no longer under direct attention. High-risk sports (e.g. skateboarding) contain risk factors that may cause individuals to reinvest in their actions more so than that of participants from less dangerous sports (e.g. golf) as stress has shown to increase reinvestment. The reinvestment of performers at latter stages of learning may not be less but conversely increase with risk from the complexity and scale of movements. This is contradictory to the predications of Fitts & Posner (1967).

The aim of the second aspect of the current study was firstly; to examine the possible differences in reinvestment due to the disparate nature of sports. Secondly, to examine the reinvestment tendencies of individuals beyond the novice level (aims 1, 3 & 7). Thus, the present research aimed to provide initial insight into reinvestment tendencies through the entire range of skill levels. It was hypothesised that high-risk sports may display higher levels of reinvestment compared to sports with a lesser inherent level of risk. Reinvestment propensity was examined to establish whether it may also be influenced as learning progresses to a more autonomous stage or to a professional status.

### 3.2.2. Methodology

#### *3.2.2.1. Participants*

Participants were recruited identically as outlined in the first part of this study mentioned previously (see page 90). A total of 613 participants currently involved within high-risk sports (skateboarding [n=501], snowboarding [n=48], BMX [n=64]) comprised the high-risk sports sample, along with 248 participants form a low-risk sporting sample (golf [n=116, swimming [n=73], discus [n=37], tennis [n=22]) (see table 1 for key demographic data). All participants involved were remained naive to the research hypothesis, until after final testing phase. All procedures were reviewed and authorised by the institution's research ethics committee. Whilst group sizes are unequal, the effect that this can have on the large samples is minimal and statistical package used is developed with

protection against issues regarding unequal sample sizes (Tabachnik & Fidell, 2007; Brace et al. 2009).

Group	N	Age (Years)	Experience (months)
High-risk sports (HR)	613	22.1 ± 5.64	86.45 ± 78.99
Low-risk sports (LR)	248	20.5 ± 2.50	69.17 ± 46.87
High-risk sports Novice (HR Nov)	114	17.32 ± 1.12	8.35 ± 2.84
Low-risk sports Novice (LR Nov)	45	17.93 ± 0.86	9.89 ± 1.43
High-risk sports Intermediate (HR Inter)	220	18.69 ± 1.81	39.29 ± 12.99
Low-risk sports Intermediate (LR Inter)	72	19.94 ± 1.41	41.89 ± 9.03
High-risk sports Expert (HR Exp)	279	26.75 ± 5.18	155.54 ± 67.45
Low-risk sports Expert (LR Exp)	131	21.69 ± 2.58	104.52 ± 35.22
High-risk sports Amateur (HR Am)	508	20.72 ± 4.56	66.61 ± 63.69
Low-risk sports Amateur (LR Am)	225	20.11 ± 2.08	60.25 ± 36.94
High-risk sports Professional (HR Pro)	105	28.77 ± 5.66	182.4 ± 75.73
Low-risk sports Professional (LR Pro)	23	24.30 ± 3.05	156.35 ± 44.88

*Table 1. Sample sizes post-categorisation based on variables; sport, experience and status (experimental study 1)*

### 3.2.2.2. Procedure

The procedure followed was identical to that outlined in the first part of this study (see page 89). The research pack mentioned earlier included an information sheet explaining a brief outline of the study, a consent form with participant details (e.g. age, experience level and time involved within their chosen sport) and a copy of the Movement Specific Reinvestment scale (Masters et al, 2005).

### 3.2.2.3. Measures

The total score of the Movement Specific Reinvestment Scale (MSRS) was used to quantify potential reinvestment in the sporting samples. Further analysis was conducted using the separate sub-scales of the MSRS known as Conscious Motor Processing (CMP) and Movement Self-Consciousness (MS-C) to identify the nature of potential reinvestment tendencies. Masters et al (2005) reported this scale reliable for both the sub-scales used showing high

test-retest reliability (CMP,  $r=0.76$  & MS-C,  $r=0.67$ ) and internal reliability (Cronbach's alpha) (CMP,  $r=0.71$ , & MS-C,  $r=0.78$ ).

### 3.2.3. Results

#### *3.2.3.1. High-risk sports vs. General Sports*

All data were checked to confirm no significant violations of normality. Bonferroni adjustments were applied where applicable on post-hoc testing. A preliminary analysis was conducted classifying the data by sporting type; high-risk sports (HR) or low-risk sports (LR). A One-way Multivariate analysis of variance (MANOVA), revealed a significant difference between sporting types on both the Conscious Motor Processing (CMP) and Movement Self-Consciousness (MS-C) sub-scales [ $F(6,854)=981.3, p<0.001$ ; Wilks Lambda  $=0.127$ ; partial  $\eta^2=0.873$ ]. Post hoc independent t-tests confirmed that High-risk Sports (HR) scored significantly higher than low-risk sports (LR) on dependent variables: CMP [ $t=18.603, df=481.684, p<0.001$ , one tailed], MS-C [ $t=25.260, df=700.825, p<0.001$ ], and MSRS [ $t=25.992, df=393.819, p<0.001$ ].

#### *3.2.3.2. 'Experience' and Reinvestment*

The data when classified by 'experience' level yielded six groups; 1. High-risk Sports Novice (HR Nov), 2. High-risk Sports Intermediate (HR Inter), 3. High-risk Sports Expert (HR Exp), 4. Low-risk Sports Novice (LR Nov), 5. Low-risk Sports Intermediate (LR Inter) and 6. Low-risk Sports Expert (LR Exp). One-way ANOVA showed significant differences between groups regarding the dependent variable MSRS total,  $F(5,860)=350.93$ ;  $p<0.001$ ; partial  $\eta^2=0.672$ . The High-risk sport groups scored significantly higher comparing Novice to Intermediate groups followed by a significant

decrease between Intermediate and Expert groups. The Low-risk Sport groups scored significantly lower through each stage of experience. HR Inter and HR Exp scored significantly higher than their Low-risk Sport counterparts (see Figure 5).

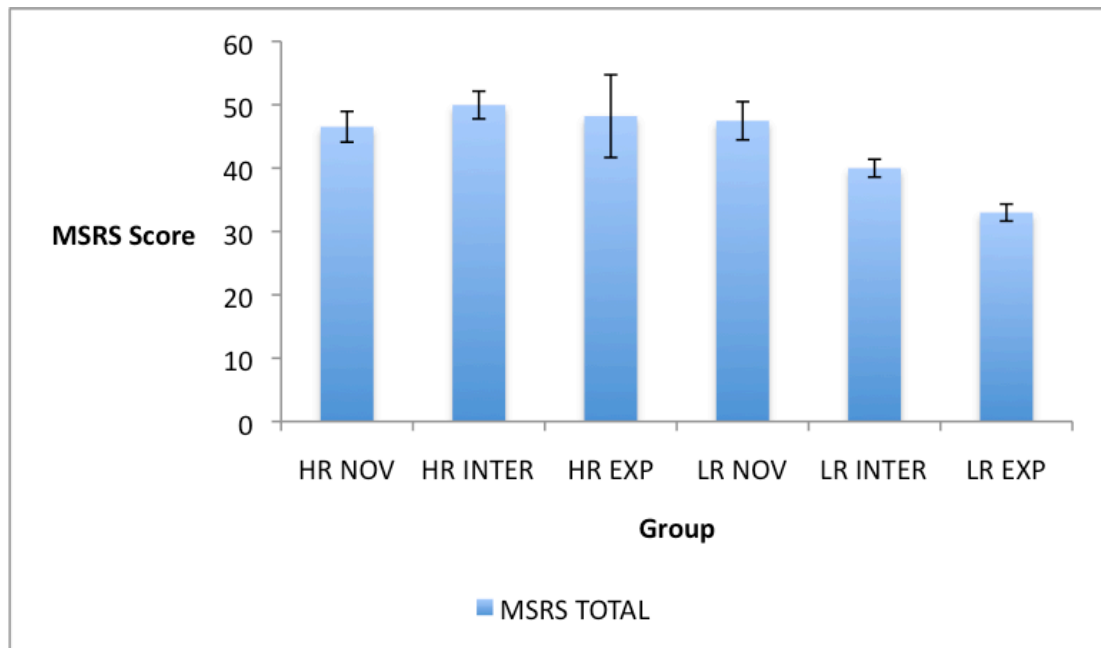


Figure 5. Mean total score for Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) for all 'experience' groups; High-risk Novice (HR NOV), High-risk Intermediate (HR INTER), High-risk Expert (HR EXP), Low-risk Novice (LR NOV), Low-risk Intermediate (LR INTER), Low-risk Expert (LR EXP) in experimental study 1.

MANOVA conducted using data from both sub-scales confirmed a significant difference regarding CMP and MS-C,  $F(30,3402)=201.74, p<0.001$ ; Wilks Lambda=0.017; partial  $\eta^2=0.56$ . Post-hoc ANOVA regarding dependent variable CMP, revealed that High-risk Sport groups significantly increased reinvestment propensity from Novice to Intermediate, followed by a significant decrease, whereas Low-risk Sports scored significantly lower throughout each progression of learning, (see Figure 2). The HR Inter and HR Exp scored significantly higher than the Low-risk Sports counterpart, whilst no significant

differences were found between LR Nov and HR Nov,  $F(5,860)= 332.37$ ;  $p<0.001$ :partial  $\eta^2=0.66$ .

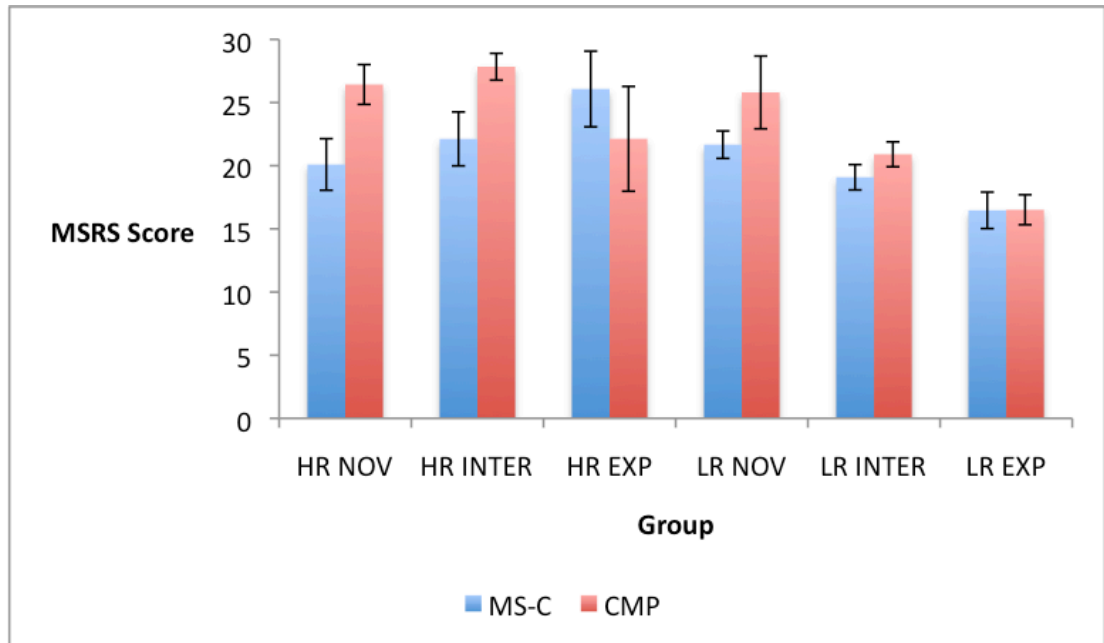


Figure 6. Score for sub-scales: Movement Self-Consciousness (MS-C) and Conscious Motor Processing for all 'experience' groups; High-risk Novice (HR NOV), High-risk Intermediate (HR INTER), High-risk Expert (HR EXP), Low-risk Novice (LR NOV), Low-risk Intermediate (LR INTER), Low-risk Expert (LR EXP) in experimental study 1.

Specific significant differences were revealed using post-hoc ANOVA on the dependent variable MS-C,  $F(5,860)= 323.98$ ;  $p<0.001$ :partial  $\eta^2=0.655$ . All high-risk sports based groups (HR Nov, HR Inter, HR Exp) scored significantly higher than their low-risk sport counterparts. High-risk sports followed a pattern of significant increase throughout each stage of experience, whereas low-risk sports illustrated the opposite by significantly decreasing through each stage of progression from Novice to Expert (see Figure 6).

### 3.2.3.3. 'Status' and Reinvestment

Finally, the data was classified into 'status' yielding four groups; High-risk Sports Amateur (HR Am), High-risk Sports Professional (HR Pro), Low-risk Sports Amateur (LR Am) and Low-risk Sports Professional (LR Pro).

The results of a two way (Sport x Status) MANOVA showed a significant difference within the dependent variables CMP and MS-C,  $F(18,2410)=239.55$ ;  $p<0.001$ ; Wilks Lambda=0.055; partial  $\eta^2=0.672$ . Post-hoc ANOVA confirmed a significant difference between groups for both sub-scales CMP [ $F(3,861)=145.282$ ;  $p<0.001$ ; partial  $\eta^2=0.337$ ], and MS-C [ $F(3,861)=404.748$ ,  $p<0.001$ ; partial  $\eta^2=0.586$ ]. A one-way ANOVA for variable MSRS confirmed the existence of a significant difference [ $F(3,861)=527.586$ ;  $p<0.001$ ; partial  $\eta^2=0.649$ ].

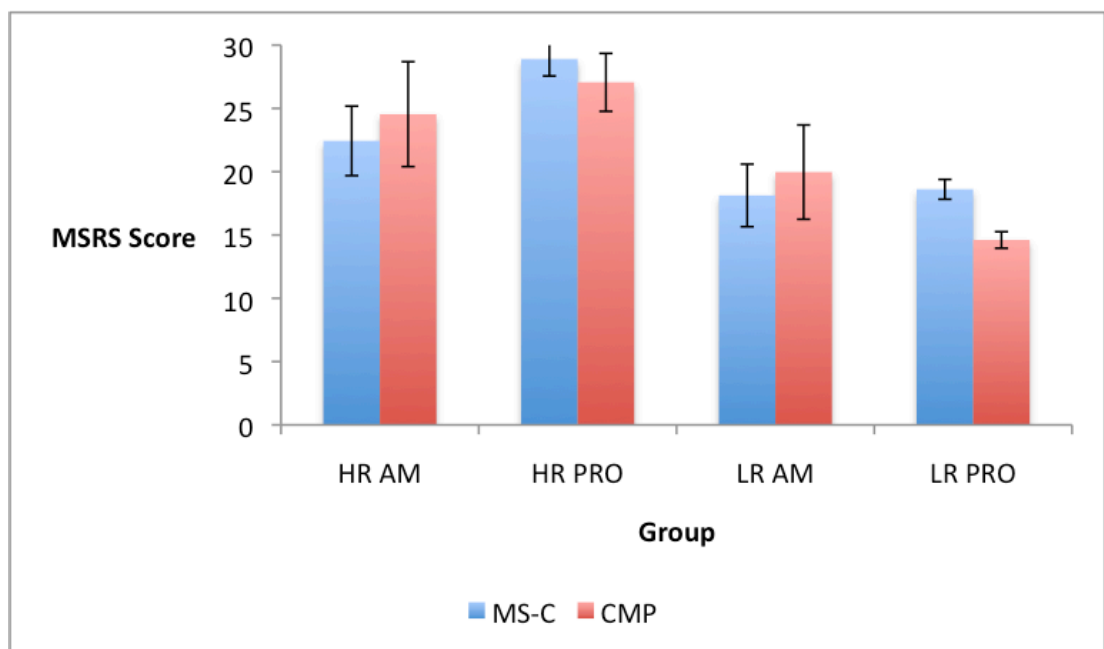


Figure 7. Mean total score of Movement Specific Reinvestment Scale (MSRS) for all 'status'; High-risk Amateur (HR AM), High-risk Professional (HR PRO), Low-risk Amateur (LR AM), Low-risk Professional (LR PRO) in experimental study 1.



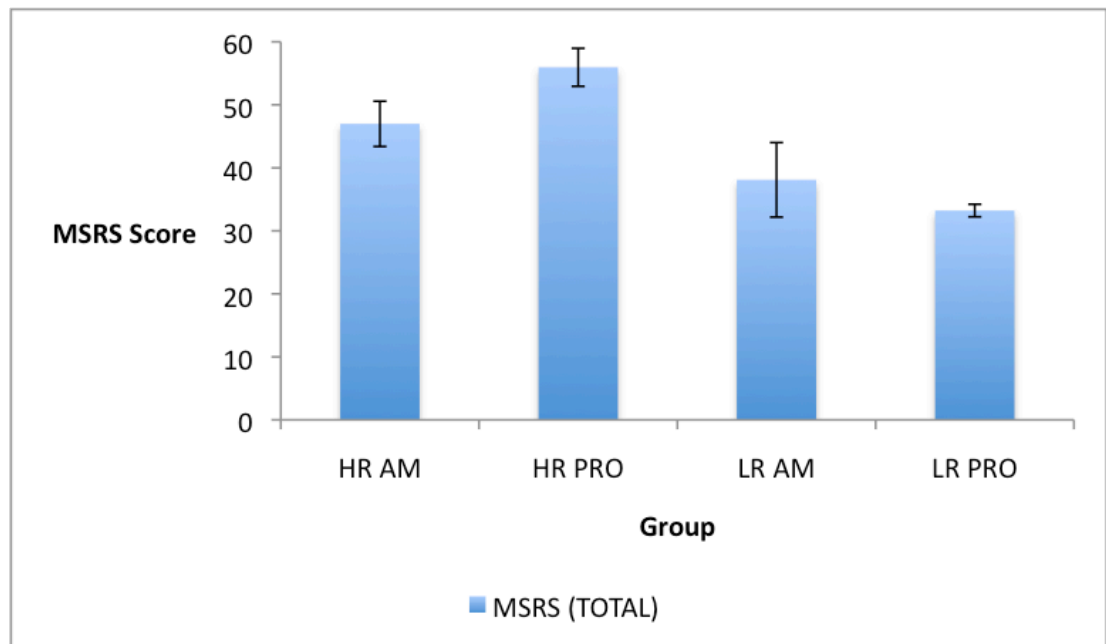


Figure 8. Mean score for sub-scales: Movement Self-Consciousness (MS-C) and Conscious Motor Processing for all 'status'; High-risk Amateur (HR AM), High-risk Professional (HR PRO), Low-risk Amateur (LR AM), Low-risk Professional (LR PRO) in experimental study 1.

In summary regarding all three variables, the HR Pro group reinvested significantly more than the HR Am group, whereas the LR Pro group reinvested significantly lower than LR Am group. Furthermore, the HR Am group reinvested significantly more than the LR Pro group. The results also show that High-risk sport groups reinvested significantly more than their Low-risk sport counterpart. These similar data trends were shown throughout all three variables; MSRS (see Figure 7), MS-C and CMP (see Figure 8).

#### 3.2.4. Discussion

The current study investigated potential differences in reinvestment propensity within a high-risk sporting sample in comparison to lower risk sports. The results confirmed that in comparing high and low-risk sporting samples, individuals engaged in high-risk sports score significantly higher on the Movement Specific Reinvestment Scale (MSRS). When dividing the data

based on 'experience' the results again showed that regardless of learning stage, those participating in high-risk sports scored significantly higher than lower risk sporting counterparts. Research to date has yet to identify this within modern day high-risk sports (e.g. skateboarding, snowboarding, BASE jumping) highlighting the originality of this research.

The nature of the reinvestment remains the same regardless of risk involved within the sport. At a novice level, the majority of the reinvestment is generated from focus on the mechanics of the movement. This is shown by results of the Conscious Motor Processing sub-scale. The data can be interpreted as whilst learning progresses through to the latter stages, the focus shifts towards the artistic, more visual demands of the task as shown by the Movement Self-Consciousness sub-scale. This finding presents support for the proposal of Movement Specific Reinvestment (Masters et al, 2005).

Significant differences are shown, however, by the trends in reinvestment within each sporting sample as progression from novice to expert occurs. High-risk sports score significantly higher throughout each stage of progression whilst lower risk sports reinvest significantly less through each stage from novice to expert. These results, in part agree with the extant literature regarding low-risk activities (e.g. tennis, golf etc). In accordance with the Multi Stage Learning Theory (Fitts & Posner, 1967), as learning progresses from a cognitive through to an autonomous stage, the skill requires less conscious control. Masters (1992), stated that because less control is required to moderate the skill consciously, the demand to reinvest becomes reduced.

The High-risk sports groups, however, contradict previous literature and tenets of both the Multi Stage Learning Theory (Fitts & Posner, 1967) and the Reinvestment Theory (Masters, 1992). Reinvestment significantly increased at each proposed stage of learning within sport groups of high-risk. This can potentially be attributed to a self-preservation mechanism.

High-risk sport participants engage in dangerous activities, whereby failure to execute the skill can result in severe physical harm. This form of stress can then result in greater reinvestment as an attempt to minimise this risk. Research has shown this may be plausible, as performers in high-risk sports have shown to be fully aware of the inherent danger, often focusing on movement control as a means of a coping strategy (Kiemle-Gabbay & Lavellee, 2017). The risk in these sports becomes greater as skill progresses due to the complexity and scale of the tasks involved. The association between reinvestment and its effect on working memory can be moderated by task complexity (Kinrade et al, 2015; Kinrade et al, 2010a).

Previous research has reported similar findings within the field of neuro-rehabilitation. Reinvestment has been found to occur as a result of fearing physical harm due to failure of successful movement patterns (Kleynen et al, 2013; Orrell et al, 2009; Wong et al, 2008; Masters et al, 2007). Medical conditions such as stroke (Danneman et al, 2018; Kal et al, 2015; Orrell et al, 2009) and Parkinson's disease (Masters et al, 2007) have damaged the neural functioning, resulting in simple tasks such as walking, becoming more cognitively demanding based on the increased difficulty in balance control and coordination. With this increase in task complexity, the risk of injury increases. In such studies the reinvestment was found to increase with the severity of the medical conditions, and thus the increased difficulty in performing the task. It

can be argued that the movement complexity of the more expert performance involves greater manipulation of skills (balance, coordination, orientation etc.) causing reinvestment to occur, in order to avoid physical harm from failure and ensure successful performance.

This phenomenon was demonstrated to a greater extent when classifying the data based on 'status'. Those engaged in high-risk sports again demonstrate significantly higher levels of reinvestment than their low-risk sports counterpart. Conflicting trends were observed when the main sample was classified according to 'status'. Professionals within high-risk sports scored significantly higher than those of amateur status; whilst those with professional status participating in lower risk sports scored significantly lower. Way (2012) claimed that participation at professional level within high-risk sports, places a great deal of stress on the individual. The movements being performed become increasingly difficult to produce based on their complexity. Rodriguez (2017) argued that success is dependent on accurate risk analysis, whereas actions become more difficult, the stress placed on the athlete becomes greater based on the risk of 'pain' from failure. This increase of stress can again be explained via the self-preservation mechanism proposed by Wong et al (2008).

The theoretical assumptions of emotional thought provided by Eysenck (1992) and Kavanagh et al (2005) could provide insight into reinvestment possibly attributed by risk. Participant perception of high-risk sports has shown to involve accepting the aspect of severe harm (Brymer & Schweitzer, 2012). This is not only accepted but can be perceived as an attractive quality of the sport (Dyrdek, 2012). The goal is to succeed embracing the risk involved within

failure. It is the understanding of this research that high-risk factors could potentially increase anxiety brought about from fear of failure. This in turn results in the focussing of attention on the movement and propensity to reinvest regarding movement.

#### 3.2.5. Summary

The reinvestment aspect of this study provided initial insight regarding reinvestment within the field of high-risk sports. The purpose of the study was to identify any potential differences concerning high-risk sports which may be attributable to the unique high-risk nature. The findings suggest that, due to the inherent risk involved with action sports, the fear of physical harm can result in an increased propensity to reinvest. Since the current study is based on a cross sectional design, causality cannot be proven. However, findings clearly suggest that as progression from novice to expert occurs, so does the reinvestment that follows. Based on previous theoretical perspectives, this should not occur. It is believed that this could be attributed to the increased risk associated with progression and participation in these sports. The present findings suggest that theories such as the Multi Stage Learning Theory cannot be applied to all categories of sport. Professional sportsmen are also at risk of reinvestment within action sports and should employ training measures (e.g. Implicit-based) that have been shown to be robust under high levels of stress in order to ensure successful performance.

Future research should aim, therefore, to explore this phenomenon further. Much research exists showing that emotions such as anxiety can significantly affect working memory, (Baddeley, 2007) and then subsequently

influence reinvestment. The extreme emotions involved in participating in high-risk sports and its relationship with reinvesting in performance are likely to be influential. Thus research should explore any possible emotional traits unique to the nature of high-risk sports. Additionally, to date, no research has shown any possible effects of how variables such as gender or age impact on the propensity to reinvest. Such research has potential value since the application of such findings can influence learning strategies which are designed to remain robust under highly stressful conditions. The design of the current study can only infer the existence of a relationship and does not prove causality based on the limitation of cross sectional design. Longitudinal studies would provide insight into the defining reasons as to why this relationship exists. Future studies should consider the mediating effects of such factors as injury history, given the potential influence on the perception of risk (Brymer & Schweitzer, 2012).

# Chapter 4

## Experimental Study 2

### ***“Skill acquisition techniques within high-risk sports at the novice stage of learning”***

#### **4.1. Introduction**

The previous study highlighted several key facets of the relationship between high-risk sports and reinvestment. Firstly, high-risk sports showed a significantly greater propensity to reinvest in movements when compared to a low-risk counterpart. More importantly, the progressive trend displayed through the learning stages from novice to experienced and then professional, was shown to be considerably different between the two sporting samples. Those engaged in high-risk sports were shown to significantly increase the propensity to reinvest progressing in experience from novice. The opposite was found as increased experience led to a significant decrease in reinvestment propensity from those participating in low-risk sports.

The popularity of high-risk sports has given rise to the demand for specialist training camps (e.g. Element YMCA). Beyond these camps, internet based companies such as Stomp, provide educational insight from professional athletes on a subscription basis where a full range of skills are demonstrated from novice through to expert. These camps aim to provide advice in skill acquisition and coaching, yet little research in the high-risk sports education exists.

Research into various coaching techniques has been examined through research in stressful scenarios, given the overwhelming impact that stress can have on working memory. Research has employed various techniques such as errorless learning (Navarro et al, 2018; Maxwell et al, 2017; Masters et al 2008a; Masters et al, 2008b; Poolton et al, 2007a), no feedback learning (Maxwell et al, 1999) and more commonly used secondary task loading (Tse et al, 2017a;2017b; Kinrade et al, 2015; Rendell et al, 2011). The most recent technique is the use of analogy learning (Liao & Masters, 2001), taking aspects of secondary task loading, whilst still maintaining some relevance to the task (for a full review of these techniques, please refer to chapter 2; p.46).

All the approaches share a common interest by attempting to neutralise the effects of reinvestment. This is defined as the manipulation of conscious, explicit, rule based knowledge and working memory, to control the mechanics of movement during skill execution, (Masters & Maxwell, 2004). The results of chapter 3 illustrate that participants in high-risk sports demonstrate a greater tendency to reinvest, potentially exposing them to greater risk of injury from skill failure. By examining this specific avenue of stress, it will provide greater validity to otherwise unexplored research in skill acquisition under stress, and support for the expanding educational facilities aforementioned.

The current chapter aims to explore the effectiveness of a range of educational techniques on skill acquisition at a novice level. This genre of sports recruits new participants on a rapid, mass scale who are at a novel stage of learning. Additionally, results from chapter 3 and existing literature are in accordance in that the novice stage of learning promotes active hypothesis testing and therefore reinvestment occurs. Given that many coaches use a



combination of either live or video instructions, the next series of studies will aim to explore any potential differences in their effectiveness.

The techniques evaluated by this study will reflect the audience being tested. Both errorless learning and no feedback learning have shown to be effective at managing reinvestment. These are however inapplicable to high-risk sports due to the excessive trial and error nature. The techniques are rooted with an extreme failure ratio that could be increasingly dangerous, placing the learner at unnecessary risk. Analogy learning has been shown to be effective (Tse et al, 2017a; 2017b; Tzetzis & Lola, 2014; Lam et al, 2009a; 2009b) and stops the learner from accumulating conscious understanding of the movement. This is again not ideally applicable, as it denies the use of such understanding at a later stage of learning whereby this knowledge is valuable (Bennet, 2000). A degree of declarative knowledge is required to provide the essential foundation to build on for future skill development or modification. Based on these criticisms, it was decided to use traditional explicit-based instructions against limited instruction only concerning the gross aspects of the movement (known as guided discovery).

## **4.2. Methodology**

### **4.2.1. Participants**

Participants (N=58) were recruited on a voluntary basis through a convenience sampling technique (see table 2 for key demographic data). All participants were required to complete a consent form (see appendix 3, for consent form exemplar) certifying the right to withdraw from the study was available at any point. All participants involved remained naive to the research hypotheses, until the end of final testing phase. All procedures were reviewed and authorised by

Teesside University research ethics committee. Participants were randomly assigned to one of five learning groups; Guided Discovery Live, Guided Discovery Video, Explicit Live, Explicit Video, and Control.

<b>Group</b>	<b>N</b>	<b>Age (Years)</b>	<b>Experience (Months)</b>
Guided Discovery-Live (GDL)	12	17.3 $\pm$ 0.65	6 $\pm$ 3.87
Guided Discovery-Video (GDV)	13	17.8 $\pm$ 1.01	5.7 $\pm$ 3.61
Explicit-Live (EXL)	12	16.7 $\pm$ 0.78	7.8 $\pm$ 3.13
Explicit-Video (EXV)	11	16.5 $\pm$ 0.69	5.6 $\pm$ 3.86
Control	10	16.8 $\pm$ 0.63	5.4 $\pm$ 4.03

*Table 2: Key demographic data for all participants in experimental study 2.*

Specific characteristics were required to prevent confounding external factors from influencing the results. Firstly, the participants were required to be of a novice stage of learning with no more experience of 12 months, participating within the sport of skateboarding. This was based on the opinion of 5 professional coaches/athletes who had competed on the international stage and are now qualified coaches, authorised by the national governing body. Participants were required to demonstrate they were able to comfortably manoeuvre on a skateboard without the previous ability of being able to perform the featured learning task (an 'Ollie').

#### 4.2.2. Variables

A total of three independent variables were manipulated throughout the testing. The result of these manipulations was then observed, and the behaviour was measured through a total of 11 dependent variables, categorised by; performance, reinvestment, and sensation seeking.

#### 4.2.2.1. Independent Variables

The first independent variable was the delivery of information through demonstration. This demonstration consisted of either an explicit nature or guided discovery delivery. The modelling consisted of a 10-minute session, where a professional skateboarder provided verbal coaching points along with visual demonstrations of the skateboarding trick known as an 'Ollie'. The Explicit conditioning of the coaching involved a total of twenty key points regarding the skill. The Guided Discovery conditioning consisted of ten key coaching points of the explicit twenty. A focus group methodology in accordance with Krueger & Casey (2009), was used to identify the coaching points chosen. These coaching points have been comprised by the previously mentioned panel of coaches, considering the most effective means of execution. The control group received no coaching points, but instead watched footage of the 2010 X-Games BMX event for the same time periods as the intervention groups' instruction. The control group was segregated at all times of the testing to avoid any unfair observational advantages.

The second independent variable was the delivery technique of the learning to the participants. The demonstrations were conveyed by using either a live model, or by video projection upon a 18ft screen. The video projection was identical in content to the live demonstration and was shown in real time from a single side view angle.

Finally, the variable of time was manipulated throughout testing the participants across three separate time periods; pre, post and retention.

#### 4.2.2.2. Dependent Variables: Performance

Three dependent variables were used to assess the performance aspect of the participants' behaviour. The primary dependent variable was the subjective score based on the execution of the skill via observation. All performances were recorded and played back to a panel of professional athletes, which rated the display of skill. This was on a scale of 1 to 10, whereby ten being superior performance. The study used a single blind approach, as the panel of judges were unaware of the group that the current participant was assigned to. The judges were instructed to compare the perceived performance to their professional opinion of a skilful execution of the skill (Ollie). This execution of skill was based on factors such as fluidity, height, composure and technique mimicking the same aspects of professional competition.

The second variable used an objective/kinematic approach, analysing the angle of the skateboard at the peak height of the movement (Ollie). The object is to bring the board level at the peak of the jump, in order to sustain maximum height and stability. Therefore, the lower (and more level) the angle of the skateboard at peak, the better the performance. Board angle was calculated through analysing high speed video footage (60Hz) using the Swinger Athlete software program to calculate peak angle.

Finally, the number of explicit rules formulated was assessed at the end of each testing phase. Explicit rules were classified as any variation or reference to the coaching points which were presented to the individual via the demonstration. This was achieved via verbal confirmation of the participant and was recorded for playback to the panel of coaches.

#### 4.2.2.3. Dependent Variables: Reinvestment

The total score of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005), was used to quantify potential reinvestment in the sporting samples. Further analysis was conducted using the separate sub-scales of the MSRS known as Conscious Motor Processing (CMP) and Movement Self-Consciousness (MS-C) to identify the nature of potential reinvestment tendencies. Masters et al (2005) reported this scale reliable for both the sub-scales used showing high test-retest reliability (CMP,  $r=0.76$  & MS-C,  $r=0.67$ ) and internal reliability (Cronbach's alpha) (CMP,  $r=0.71$ , & MS-C,  $r=0.78$ ).

#### 4.2.2.4. Dependent Variables: Sensation Seeking

The total score of the Sensation Seeking Scale V (SSSV) (Zuckerman, 1978), was used to quantify sensation seeking. This was analysed along with subsequent analyses conducted using the four separate sub-scales; Thrill & Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS), and Disinhibition (Dis).

#### 4.2.3. Demonstration

The demonstration was given by a twenty-seven year old male, approximately three meters away from the participant. The task was performed using the apparatus below and was viewed from a side position in to achieve a clear, holistic view of the target skill. Audio was available by the demonstrator narrating the task as he completed the movement. This was in accordance with the parameters set by the learning condition. The skill was fully demonstrated approximately twenty times throughout the demonstration. The demonstrator was instructed to follow the same procedure for each of the live

demonstrations, as well the single videotaped demonstration. The same videotaped demonstrations were used for both the post and retention testing.

#### 4.2.4. Apparatus

All testing and acquisition phases were conducted at R-Kade Skate-park in Redcar, England. All video recording was performed using an Olympus i-Speed 2 high speed camcorder and kinematic analysis was carried out using Swinger software. Safety equipment consisted of elbow and knee pads, (TSG) and a helmet (Stateside) was available, whilst participants used their own personal equipment.

#### 4.2.5. Procedure

Once all participants had reviewed and completed the participant information sheet, providing consent to participation in the following study, baseline testing procedures began. The protocol adopted an A-B-A-A design which consisted of three tests phases (A) and a single acquisition period (B). The testing phases (pre, post, and retention) followed the same protocol consisting of the participant executing ten consecutive Ollie's individually, in their own time. This performance was recorded using a high speed video-camera, positioned in front of the participant, and played back for subjective and kinematic analyses. The participants completed both the MSRS and SSSV following the completion of the motor performance.

The participants were randomly assigned to each of five groups (see table 2 for group sizes), each of whom were subjected to a different learning intervention throughout the testing period. There were two guided discovery groups which were instructed using demonstrations based on the ten coaching points from the guided discovery instruction sheet (appendix 4). The Guided

Discovery-Live group [GD-L] viewed demonstrations from a live model and the Guided Discovery-Video group [GD-V] were educated via the video footage taken prior to protocol. The same was repeated within the Explicit learning for both the Explicit-Live group [EX-L] and the Explicit-Video group [EX-V]. The explicit-based groups received a total of twenty detailed instructions regarding the execution of the skill (appendix 5). This included positioning of arms, centre of gravity etc., along with detailed focus on the co-ordination of their movements. These coaching points were agreed upon by the five coaches involved. Finally a control group was included which received no tuition throughout the protocol.

Once the initial baseline testing phase was completed, the acquisition stage began the following week. The acquisition stage lasted a period of four weeks, with two coaching sessions per week. The session began with the presentation of the learning stimuli for a total of ten minutes, the participants then began twenty minutes of motor practice. Following this, the learning stimuli were demonstrated again, followed by a further twenty minutes of practice. This is in accordance with the guidelines of Landers (1975) for the most effective Observational learning to occur. The Control group spent the same period of time viewing footage of the 2010 X-Games competition where no instructions were present or displayed.

Upon completion of the four-week acquisition phase, a post test was immediately conducted. This was the same procedure as the pre-test. This consisted of asking the participants to recall how many of the coaching points they can remember. This interview was recorded and played back to assess how many rules were recalled in the participants own words.

A retention period of two weeks occurred where no further teaching interventions took place. All participants were instructed not to undergo any further practice of the skill in question. At the end of the retention period, a third testing protocol was conducted, following the same procedure as the post-test. This then concluded the procedure and each participant was fully debriefed and provided with contact details for further enquiries. The results were then statistically analysed using the statistical software (SPSS version 22) to assess each of the five groups' scores from the dependent variables listed. The analyses also examined the effect of time from across all three assessment periods.

### 4.3. Results

All data were checked to confirm there were no significant violations of normality. Bonferroni adjustments were applied where applicable on post-hoc testing. Results of a two way (3x5) (Time x Group) MANOVA, revealed a significant effect for both 'Group',  $F(36,57.604) = 22.002$ ,  $p < 0.001$ ; Wilks Lambda=0.038; partial  $\eta^2=0.559$  and 'Time',  $F(18,302) = 55.147$ ,  $p < 0.001$ ; Wilks Lambda=0.054; partial  $\eta^2=0.767$ . Analyses also report a significant interaction between these two effects,  $F(72,926.076) = 6.807$ ,  $p < 0.001$ ; Wilks Lambda = 0.075; partial  $\eta^2=0.276$ .

In accordance with Tabachnik & Fidell (2007), an additional, separate two way (3x5) (Time x Group) MANOVA was also conducted on the total scores for both Sensation Seeking and Movement Reinvestment as these would be correlated with other variables (respected sub-scales) in the analysis based on the scoring of the scales. Analyses confirm similar findings whereby a significant effect occurred regarding 'Group',  $F(8,316) = 24.338$ ,  $p < 0.001$ ; Wilks Lambda = 0.383; partial  $\eta^2=0.381$ , and 'Time',  $F(4,316) = 21.496$ ,  $p < 0.001$ ; Wilks



Lambda = 0.618; partial  $\eta^2 = 0.214$ . Analyses confirm a significant 'Group x Time' interaction,  $F(16,316) = 8.845, p < 0.001$ ; Wilks Lambda = 0.477; partial  $\eta^2 = 0.309$ .

The study followed a mixed design, whereby each of the five groups were compared with their respective performance of the group (within), but also with one another (between) during each tested time phase. This concerned all variables tested and have been categorised based on the nature of their focus; performance, reinvestment propensity, or sensation seeking tendency.

#### 4.3.1. Performance Variables

##### Subjective Analysis (SUB): Judges' Score

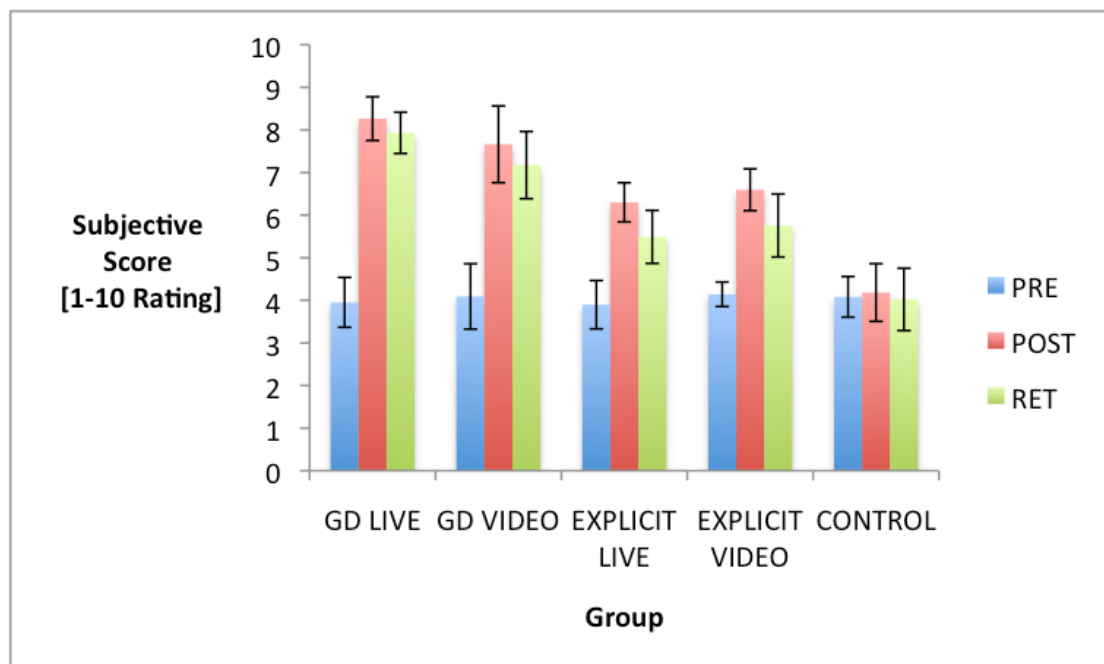


Figure 9. Mean subjective scoring across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

As can be seen in Figure 9, all five groups scored equally during the initial pre (baseline) testing stage. During the other testing stages, although all four intervention groups significantly improved their performance, the GDL and

GDV groups scored highest ranking 1st and 2nd in both the post and retention stages. Guided discovery groups also showed less of a debilitating effect from the retention period.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirmed a significant effect for the Subjective analysis variable (SUB) on the GDL group,  $[F(1.345, 14.792) = 543.759, p < 0.001; \eta^2 = 0.98]$ . Significant improvements in performance were shown pre-post and overall (pre-retention), with no significant difference post-retention.

Post-hoc one-way ANOVA also confirmed a significant effect for the groups GDV  $[F(2, 24) = 299.333, p < 0.001; \eta^2 = 0.961]$ , EXL  $[F(2, 22) = 121.532, p < 0.001; \eta^2 = 0.917]$  and EXV  $[F(2, 20) = 82.849, p < 0.001; \eta^2 = 0.892]$ . In all three cases a similar trend was observed. Significant improvements in performance were observed between pre-post and overall but displayed a significant decline in performance post-retention.

Post-hoc analysis for the variable SUB, confirmed no significant differences within any of the three testing stages for the control group  $[F(2, 18) = 0.387, ns; \eta^2 = 0.041]$ .

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage,  $[F(4, 53) = 0.34, ns]$ .

Post-hoc analysis confirmed significant differences between the groups for the post-test stage,  $[F(4, 53) = 65.675, p < 0.001]$  and retention testing stage,  $[F(4, 53) = 55.954, p < 0.001]$ . In both instances, the same trends were identified.

Guided Discovery based groups performed significantly better than their explicit-based counterpart, whilst no significant differences were found between live and video based respective groups. All intervention groups performed significantly better than the control group.

*Kinematic Analysis (KIN): Optimal board angle*

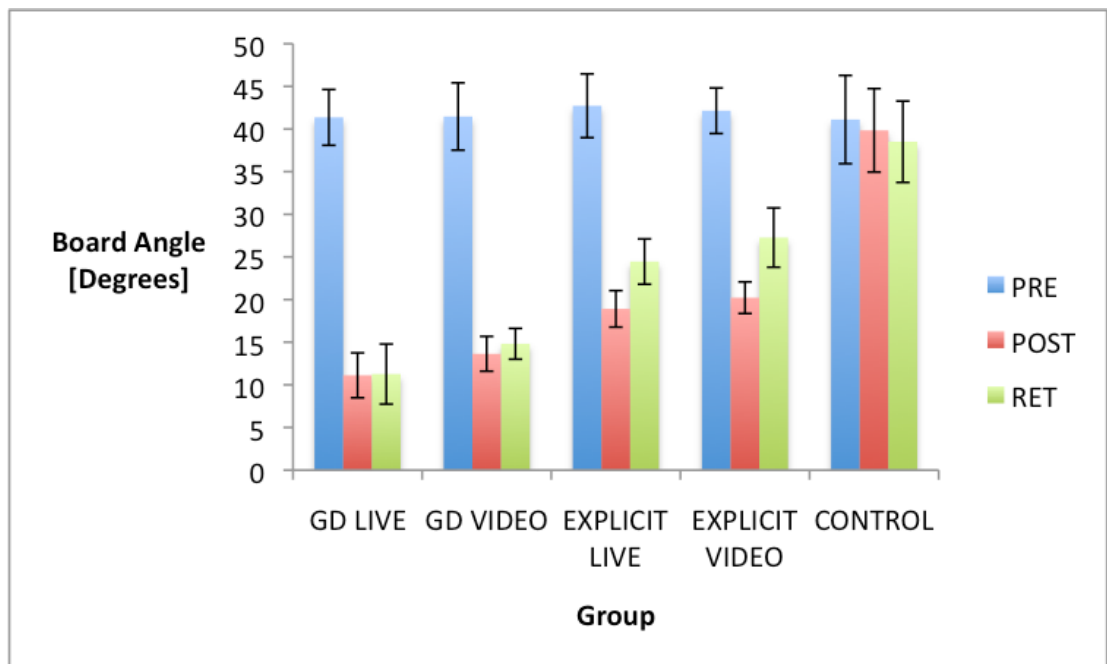


Figure 10. Mean kinematic analysis for the angles of skateboard at peak height across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figure 10 shows an equal spread of performance across all five groups at pre (baseline) testing. Guided discovery-live group showed the best performance throughout later testing stages and was almost unaffected by a retention period. The explicit learning based groups, however, appear to have their performance hindered by the break following acquisition. The performance of the control group although remained significantly unaffected, it is clear that a regressive trend is occurring.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirmed a significant effect within the Kinematic analysis variable (KIN), for both the Guided Discovery-Live (GDL), [ $F(2,22) = 548.648$ ,  $p < 0.001$ ;  $\eta^2 = 0.98$ ] and Guided Discovery-Video (GDV), [ $F(1.275, 15.303) = 583.589$ ,  $p < 0.001$ ;  $\eta^2 = 0.98$ ]. Post-hoc analysis showed that GDL and GDV displayed similar trends by performing significantly better both pre-post and overall, whilst showing no significant difference in performance post-retention.

The Explicit-Live (EXL) and Explicit-Video (EXV) groups also demonstrated matched pattern of performance throughout testing. Post-hoc one-way ANOVA revealed a significant effect for both the EXL group, [ $F(2,22) = 251.158$ ,  $p < 0.001$ ;  $\eta^2 = 0.958$ ], and EXV group, [ $F(2,20) = 161.535$ ,  $p < 0.001$ ;  $\eta^2 = 0.942$ ]. The results show that both groups performed significantly better pre-post and overall, but unlike the Guided Discovery learning groups, EXL and EXV suffered a significant decline in performance post-retention.

Post-hoc one-way ANOVA confirmed no significant changes in performance by the control group between any of the testing stages, [ $F(2,18) = 4.566$ , ns;  $\eta^2 = 0.337$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,53) = 0.382$ , ns].

Post-hoc analysis confirmed significant differences between the groups for the post-test stage, [ $F(4,53) = 65.675$ ,  $p < 0.001$ ] and retention testing stage, [ $F(4,53) = 55.954$ ,  $p < 0.001$ ]. Identical trends were identified within both stages.

Guided Discovery based groups performed significantly better than their explicit-based counterpart, whilst no significant differences were found between the respective live and video based groups. All groups who underwent a learning intervention performed significantly better than the control group.

*Explicit Rules Formulated (RULES)*

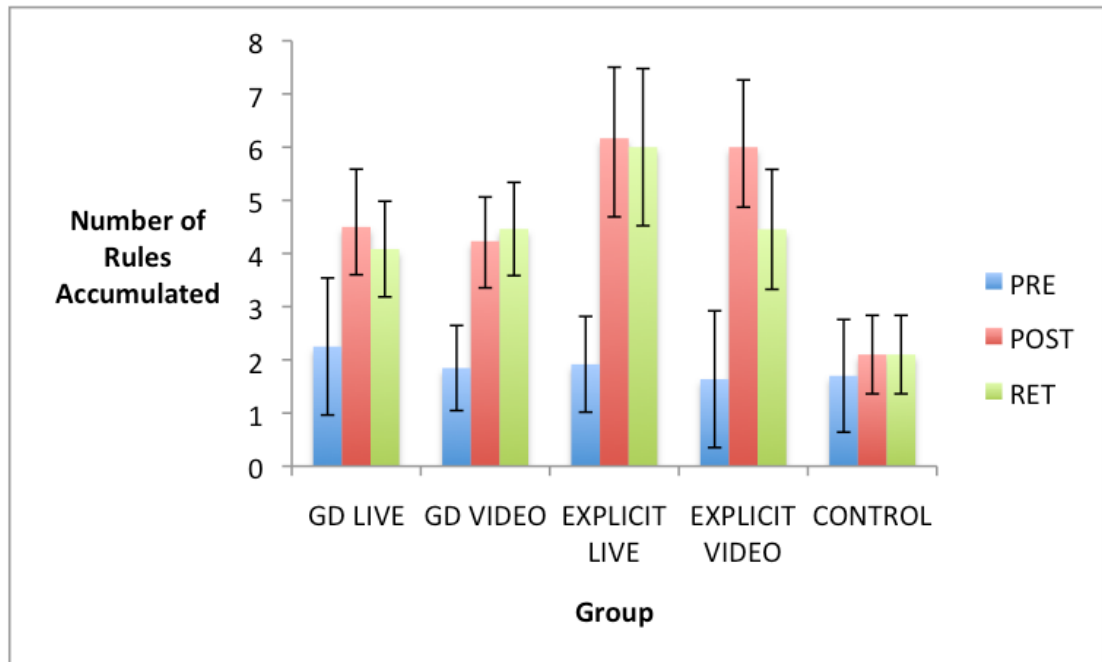


Figure 11. Mean number of explicit rules recalled across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figure 11 shows the number of the explicit rules recalled by each of the groups throughout testing. All groups showed an increase in recollection, however the explicit-based groups recalled the most, with the EXL group maintaining this in both latter stages. The retention period had differing effects on the groups. All groups barring the GDV showed a debilitating effect from the retention period, whereas it appears to have unaffected (if not aided) the GDV group.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirmed significant differences within the groups GDL,  $[F(2,22) = 18.061, p < 0.001; \eta^2 = 0.062]$ , GDV,  $[F(2,24) = 95.910, p < 0.001; \eta^2 = 0.889]$ , EXL,  $[F(2,22) = 37.358, p < 0.001; \eta^2 = 0.773]$  and EXV,  $[F(2,20) = 40.945, p < 0.001; \eta^2 = 0.804]$ . Post-hoc analyses revealed that all four learning intervention groups (GDL, GDV, EXL, EXV) significantly increased the number of memorised explicit rules pre-post and overall, whilst showing no significant difference post-retention.

Post-hoc analysis revealed no significant differences within the control group during any of the three testing phases or overall,  $[F(2,18) = 0.742, ns; \eta^2 = 0.076]$ .

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage,  $[F(4,53) = 0.571, ns]$ .

Post-hoc analysis confirmed a significant difference for both testing stages post,  $[F(4,53) = 24.676, p < 0.001]$  and retention,  $[F(4,53) = 18.674, p < 0.001]$ . During the post stage, Guided Discovery based groups recalled significantly less rules than their explicit learning based counterpart. This was not the case in the retention testing as 'Guided Discovery-Live' recalled significantly less than 'Guided Discovery-Video', and again no significant differences were found between the two explicit-based groups. All other trends were identical throughout both the post and retention stages of testing. No significant differences were found between live and respective video based counterparts. All groups recalled significantly more rules than the control group.

### 4.3.2. Reinvestment variables.

#### Movement Specific Reinvestment Scale: Total score (MSRS)

Figure 12 shows the trends in reinvestment from all the groups. The guided discovery based groups and control, showed minimal change from the pre-testing (baseline) measures. Those in the guided discovery groups appear to have a reduction (significant in the case of GDL) in reinvestment during the post testing, yet this was not sustained following the retention period. The opposite can be seen by that of the explicit-based learning, where an increase in reinvestment occurs and is maintained through testing.

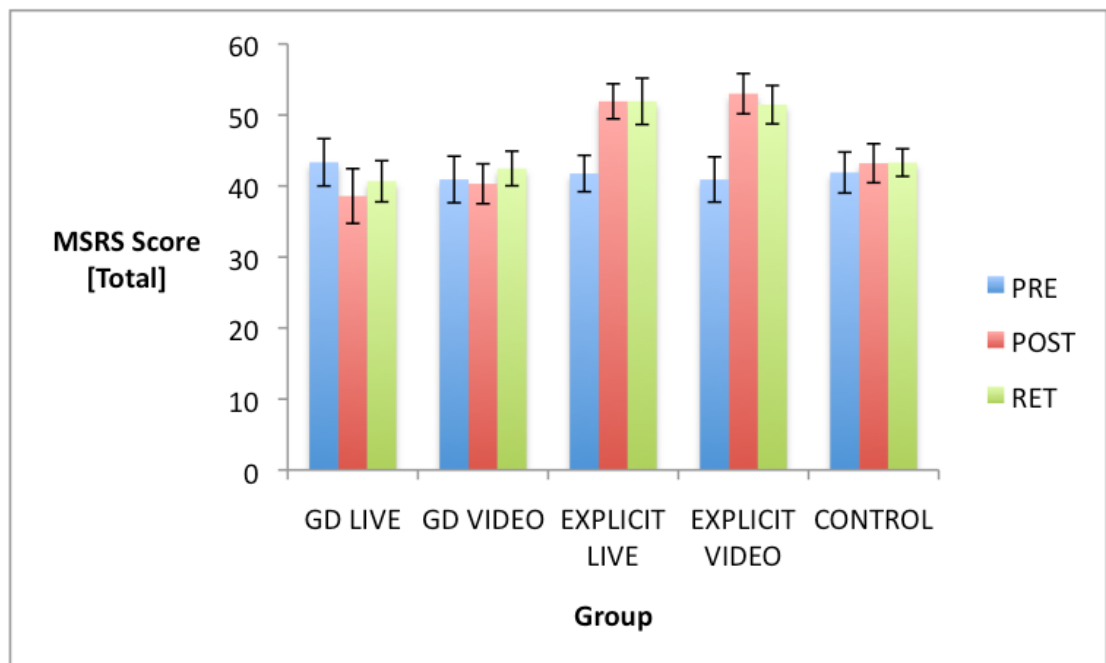


Figure 12. Mean total score for the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirmed a significant effect within the group 'Guided Discovery-Live' (GDL), [ $F(2,22) = 7.717$ ,  $p < 0.05$ ;  $\eta^2 = 0.412$ ]. Analysis shows that MSRS significantly decreased between pre-post testing within no significant differences post-retention or overall. One-way ANOVA confirmed significant differences within the groups 'EXL', [ $F(2,22) = 79.943$ ,  $p < 0.001$ ;  $\eta^2 = 0.879$ ] and 'EXV', [ $F(2,20) = 63.452$ ,  $p < 0.001$ ;  $\eta^2 = 0.864$ ]. Both groups demonstrate identical trends, whereby a significant increase in MSRS occurs both pre-post and overall, with no significant difference during post-retention.

Post-hoc analysis confirmed no significant differences between any testing phase within either of the control, [ $F(1.302, 11.714) = 0.897$ , ns;  $\eta^2 = 0.091$ ] or 'Guided Discovery-Video' (GDV) group, [ $F(2,20) = 5.593$ ,  $p < 0.001$ ;  $\eta^2 = 0.864$ ].

*Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,53) = 1.246$ , ns].

Post-hoc one-way ANOVA revealed a significant effect between groups in the testing stages; post, [ $F(4,53) = 58.559$ ,  $p < 0.001$ ] and retention, [ $F(4,53) = 47.247$ ,  $p < 0.001$ ]. Pairwise comparisons reveal that Guided Discovery based groups reinvested significantly less than their explicit learning counterparts, and no significant differences were found between respective live and video groups. Both 'Explicit-Live' and 'Explicit-Video' reinvested significantly more



than the control group. Those educated by means of guided discovery however, reinvested significantly less than the control group.

*Conscious Motor Processing: subscale score (CMP)*

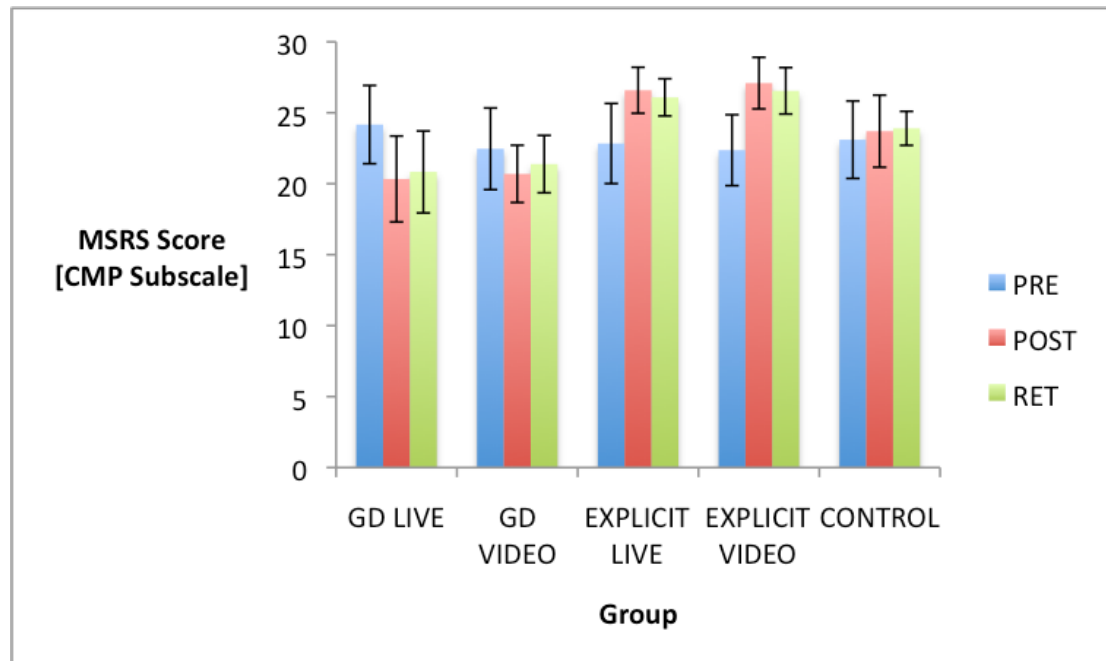


Figure 13. Mean scores from the Conscious Motor Processing subscale (CMP) of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005)) across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figure 13 displays similar scores from all groups in the initial pre-testing (baseline). Following learning interventions, those educated by explicit means showed an increase in their reinvestment, whilst those educated by guided discovery showed an opposite effect. The guided discovery-live group showed the greater reduction, whilst the explicit learning-video showed the greatest increase from pre-test measures.

*'Within Perspective' (pre vs post vs retention)*

One-way ANOVA confirmed a significant effect within the group 'Guided Discovery-Live' (GDL). Analysis revealed that the scores significantly decreased both pre-post and overall, whilst showing no significant difference post-retention.

A significant effect was confirmed for both explicit-based learning groups, [EXL,  $F(1.357, 14.926) = 20.083$ ,  $p < 0.001$ ;  $\eta^2 = 0.646$ ] and [EXV,  $F(2, 20) = 16.687$ ,  $p < 0.001$ ;  $\eta^2 = 0.625$ ]. Both groups demonstrated identical trends, showing a significant increase in scores pre-post and overall, with no significant difference post-retention.

One-way ANOVA revealed no significant differences between any of the testing stages within either group; 'Guided Discovery-Video' (GDV), [ $F(2, 24) = 1.842$ , ns;  $\eta^2 = 0.133$ ] and control, [ $F(2, 18) = 0.829$ , ns;  $\eta^2 = 0.084$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4, 53) = 0.827$ , ns].

Post-hoc analysis confirmed a significant effect between groups during the post, [ $F(4, 53) = 23.555$ ,  $p < 0.001$ ], and retention, [ $F(4, 53) = 21.662$ ,  $p < 0.001$ ] stages of testing. Pairwise comparisons show that in both cases, those educated by means of guided discovery reinvested significantly less than their explicit-based counterpart, and that no differences were found between the live and their respective video groups. Explicit-based learning groups reinvested significantly more than the control group in both the post and retention testing

stages. The trends of the guided discovery groups differed when compared to the control in relation to the testing stage. Analyses showed the GDV group reinvested significantly less than the control group, with no significant difference between the GDL and control. Retention testing showed no significant differences between either of the guided discovery groups and control.

*Movement Self-Consciousness: subscale score (MS-C)*

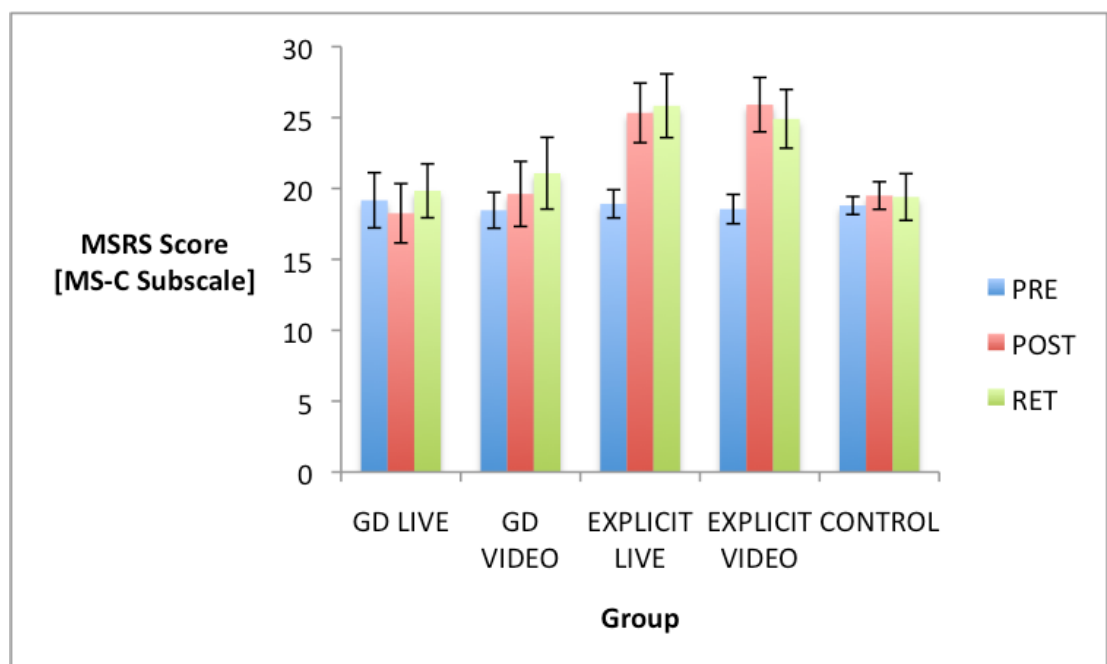


Figure 14. Mean scores from the Movement Self-Consciousness subscale (MS-C) of the Movement Specific Reinvestment Scale (Masters et al, 2005), across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

The reinvestment patterns displayed in Figure 14 correspond to the scores shown for the Conscious Motor Processing sub-scale (Figure 13). Minimal change is seen overall by guided discovery throughout testing. Explicit-based groups not only significantly increased their scores, but also sustained the heightened reinvestment following retention. Minor increases were observed by the control groups but remained insignificant.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirmed a significant effect for the explicit-based learning groups; [EXL,  $F(2,22) = 59.862$ ,  $p < 0.001$ ;  $\eta^2 = 0.845$ ], and [EXV,  $F(2,20) = 62.269$ ,  $p < 0.001$ ;  $\eta^2 = 0.862$ ]. The groups' scores significantly increased pre-post and overall but showed no significant change post-retention.

Post-hoc analysis confirmed no significant effect within the groups; GDL, [ $F(2,22) = 1.797$ , ns;  $\eta^2 = 0.140$ ] and control, [ $F(2,18) = 0.352$ , ns;  $\eta^2 = 0.038$ ].

A significant effect was reported for the group GDV, [ $F(2,24) = 4.188$ ,  $p < 0.05$ ;  $\eta^2 = 0.259$ ], however, analysis show a significant increase in reinvestment score overall with no significant differences pre-post and post-retention.

*'Between Perspective' (all groups)*

Post-hoc ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,53) = 0.607$ , ns].

Post-hoc one-way ANOVA revealed a significant effect between groups in the testing stages; post, [ $F(4,53) = 38.77$ ,  $p < 0.001$ ] and retention, [ $F(4,53) = 22.182$ ,  $p < 0.001$ ]. Pairwise comparisons reveal that Guided Discovery based groups reinvested significantly less than their explicit learning counterparts, and no significant differences were found between respective live and video groups. Both 'Explicit-Live' and 'Explicit-Video' reinvested significantly more than the control group. Those educated by means of guided discovery however, reinvested significantly less than the control group.

### 4.3.3. Sensation Seeking variables

#### Sensation Seeking Scale V: total score (SSSV)

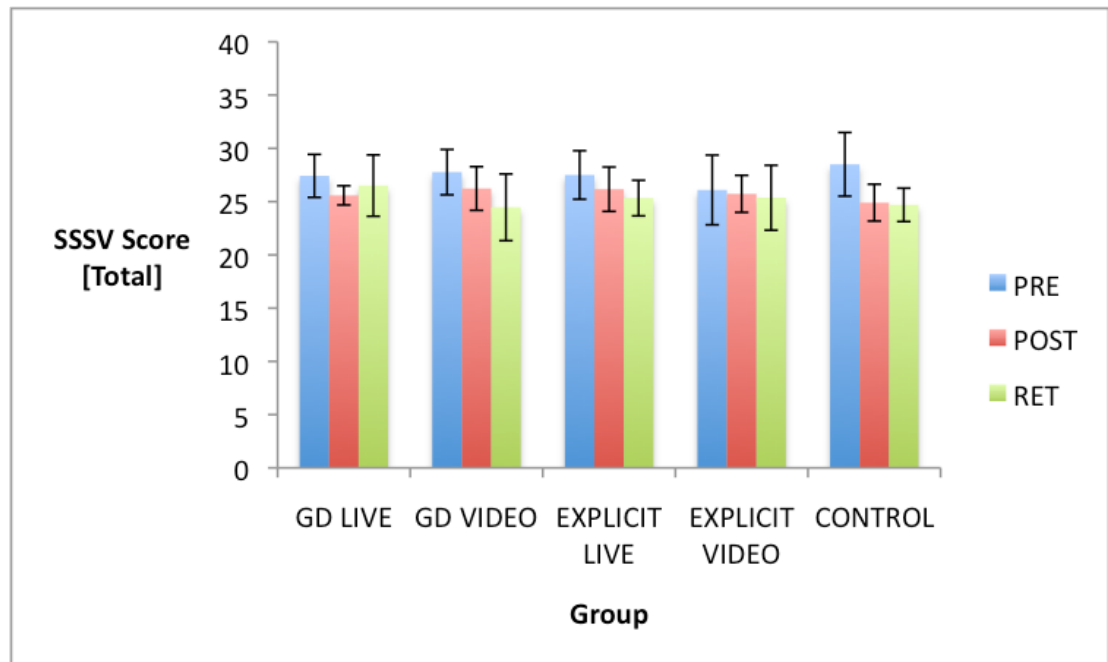


Figure 15. Mean total score from the Sensation Seeking Scale V (SSSV) (Zuckerman, 1978), across all three testing stages in experimental study 2 for all groups: Guided Discovery-Live (GDL), Guided Discovery-Video (GDV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Shown in Figure 15, all groups scored similarly high on sensation seeking tendencies. These remained stable throughout testing and this trend was shown for the subsequent sub-scales.

#### *'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA revealed a main effect within the group 'Guided Discovery-Video' (GDV), [ $F(2,24) = 7.117$ ,  $p < 0.05$ ;  $\eta^2 = 0.372$ ]. Scores significantly decreased overall from pre-retention, and no significant differences were identified between pre-post or post-retention.

All other groups were found to have no significant differences between any of the testing stages; GDL, [ $F(2,22) = 2.802$ , ns;  $\eta^2 = 0.203$ ], [EXL,  $F(2,22) = 3.478$ ,

ns;  $n^2=0.24$ ], [EXV,  $F(2,20) = 3.322$ , ns;  $n^2=0.249$ ] and control, [ $F(2,18) = 0.984$ , ns;  $n^2=0.099$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA revealed no significant differences between any of the groups at any stage of testing; Pre, [ $F(4,53) = 0.858$ , ns], Post, [ $F(4,53) = 1.022$ , ns] or Retention, [ $F(4,53) = 1.126$ , ns].

*Thrill & Adventure Seeking: subscale score (TAS)*

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences within any of the groups tested; GDL, [ $F(2,22) = 0.25$ , ns;  $n^2=0.022$ ], GDV, [ $F(2,24) = 3.403$ , ns;  $n^2=0.221$ ], EXL, [ $F(2,22) = 5.684$ , ns;  $n^2=0.341$ ], [EXV,  $F(2,20) = 2.187$ , ns;  $n^2=0.179$ ] and control, [ $F(2,18) = 0.921$ , ns;  $n^2=0.093$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA revealed no significant differences between any of the groups at any stage of testing; Pre, [ $F(4,53) = 1.569$ , ns], Post, [ $F(4,53) = 1.195$ , ns] or Retention, [ $F(4,53) = 0.353$ , ns].

*Experience Seeking: subscale score (ES)*

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA revealed a main effect within the group 'Guided Discovery-Video' (GDV), [ $F(2,24) = 12.587$ ,  $p<0.001$ ;  $n^2=0.512$ ]. Scores significantly decreased overall from pre-retention, and no significant differences were identified between pre-post or post-retention.

All other groups were found to have no significant differences between any of the testing stages; GDL,  $[F(2,22) = 1.361, ns; n^2=0.11]$ , EXL,  $[F(2,22) = 3.194, ns; n^2=0.225]$ , EXV,  $[F(2,20) = 2.187, ns; n^2=0.179]$  and control,  $[F(2,18) = 1.077, ns; n^2=0.107]$ .

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA revealed no significant differences between any of the groups at any stage of testing; Pre,  $[F(4,53) = 1.831, ns]$ , Post,  $[F(4,53) = 1.744, ns]$  or Retention,  $[F(4,53) = 0.707, ns]$ .

*Boredom Susceptibility: subscale score (BS)*

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA revealed a main effect within the group 'Explicit Learning-Video' (EXV),  $[F(2,20) = 5.593, p<0.05; n^2=0.359]$ . Scores significantly decreased overall from pre-retention, and no significant differences were identified between pre-post or post-retention.

All other groups were found to have no significant differences between any of the testing stages; GDL,  $[F(2,22) = 1.453, ns; n^2=0.117]$ , GDV,  $[F(1.331, 15.969) = 3.087, ns; n^2=0.205]$ , EXL,  $[F(2,22) = 3.763, ns; n^2=0.255]$  and control,  $[F(2,18) = 4.421, ns; n^2=0.329]$ .

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA revealed no significant differences between any of the groups at any stage of testing; Pre,  $[F(4,53) = 1.286, ns]$ , Post,  $[F(4,53) = 0.741, ns]$  or Retention,  $[F(4,53) = 2.599, ns]$ .

Disinhibition: subscale score (DIS)*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences within any of the groups tested; GDL,  $[F(2,22) = 0.733, ns; n^2=0.063]$ , GDV,  $[F(2,24) = 0.288, ns; n^2=0.023]$ , EXL,  $[F(1.256,13.82) = 1.335, ns; n^2=0.108]$ , EXV,  $[F(2,20) = 0.329, ns; n^2=0.032]$  and control,  $[F(1.305,11.743) = 0.589, ns; n^2=0.061]$ .

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA revealed no significant differences between any of the groups at any stage of testing; Pre,  $[F(4,53) = 0.377, ns]$ , Post,  $[F(4,53) = 1.259, ns]$  or Retention,  $[F(4,53) = 0.632, ns]$ .

**4.4 Discussion**

The results of experimental study 2 show that there are several key points to note regarding the effectiveness of learning interventions in a high-risk sport. It is important to note that although no change was seen between any groups at any point regarding Sensation Seeking, the values recorded are indicative of an individual engaged in risky, dangerous behaviours (Zuckerman, 2007).

Firstly, regarding performance, though four variations of learning intervention were applied, all four successfully improved overall performance significantly, when comparing both subjective and objective pre-testing (baseline) to retention measures. The control group however, showed no significant change



in performance throughout testing, supporting the internal validity of the study's subsequent findings. The retention period consisting of two weeks with no instruction showed to be effective at evaluating the durability of acquired skills.

Following the retention period, neither group educated via Guided Discovery were affected, whilst those in the Explicit learning grouping showed a significant decline in the objective performance measure (KIN). Only individuals within the Guided Discovery-Live group were unaffected by the retention period, whilst all remaining intervention groups suffered a significant decline in the subjective performance measure (SUB).

Both the explicit and guided discovery interventions were shown to be significantly effective at improving performance. When directly compared with one another Guided Discovery performed significantly better than the Explicit counterpart (in reference to live or video format). No significant differences were identified in performance between video and live demonstration regardless of intervention applied. This lack of effect was seen across all variables, suggesting no significance regarding video delivery or live demonstration.

This superiority in performance by less explicit means has been shown in other research (Tse et al, 2017a; 2017b; Tzetzis & Lola, 2015; Lam et al, 2009a; 2009b; Masters et al, 2008a; 2008b; Gucciardi & Dimmock, 2008; Poolton et al, 2007b; Liao & Masters, 2001). The current study has expanded on the findings of previous research by providing support utilising a complex, whole-body movement with the co-ordination of gross motor skills. Furthermore, the use of physical risk as a stressor has yet to be implemented within a sporting task to assess the potential benefits of implicit-based learning

strategies. The results confirm the benefits of implicit-based learning strategies within skill acquisition of high-risk sports at a novice level.

A potential theoretical explanation of these results was noted previously in chapter two, known as the Attentional Control Theory (ACT) (Eysenck et al, 2007). This theory identified precise functions of the central executive (within working memory model proposed by Baddeley, 2000), responsible for attentional control and fail to work effectively when cognition is subjected to anxiety. ACT suggests that anxiety affects both the capacity and ability to maintain effective attentional control, by redirecting attention both within and between tasks as required (referred to as the shifting function). Conversely, it also affects the ability to inhibit attention of unimportant or otherwise irrelevant stimuli and responses (known as the inhibition function).

Arousal in the form of anxiety is understood to impact the performance efficiency of both shifting and inhibition functions, the performance effectiveness is believed to be less effected (Derakshan & Eysenck, 2009). This can be seen within the performance variables of the current study. All four groups significantly improved whilst maintaining performance effectiveness, but the increased levels of anxiety may have potentially influenced performance efficiency. This was shown less in the implicit-based groups where there was a lower cognitive strain given the minimal declarative knowledge available. Although the performance was completed, implicit-based groups scored significantly higher on subjective performance, of which movement efficiency is a priority.

The use of less declarative knowledge from environmental stimuli is theorised to be advantageous concerning the Inverted U theory of arousal (Yerkes &

Dodson, 1908). It suggests that all activities require an optimal level of arousal to perform most effectively. When arousal is under the optimum, attentional cues can be missed due to lack of attention. When arousal becomes heightened beyond the optimal level, cues are missed because of an overload to sensory system. This is similarly echoed within the catastrophe theory (Hardy & Fazey, 1987) whereby when somatic anxiety is redeemed as debilitating to performance when coupled with high cognitive anxiety. The demands from the more explicit-based teaching within a high-risk sport, could push the subject beyond the optimal level of arousal. In accordance with ACT, this would directly impact the shifting and inhibition function. Research has shown that performance is significantly impaired when these functions are affected negatively (Derakshan et al, 2011; Pacheo-Unguetti et al, 2010; Johnson, 2009; Reinholdt-Dunne et al, 2009; Derakshan et al, 2009b; Garner et al, 2009; Wieser et al, 2009; Ansari et al, 2008; Bar-Haim et al, 2007; Miyake et al, 2000).

This overwhelming effect of working memory and attentional processes is represented in the current study. Although all four intervention groups acquired significantly more explicit knowledge in comparison to baseline measures, groups educated via explicit means were shown to recall significantly more consciously acquired knowledge against Guided Discovery groups. Despite less explicit knowledge being demonstrated to Guided Discovery groups, performance remained significantly superior and was shown to be more retentive, whilst being less consciously accessible.

Results regarding number of explicit rules recalled lends support to the argument of conscious accessibility. Groups educated by explicit means recalled significantly more rules regarding skill execution compared to guided

discovery. This reinforces not only the concept of allowing those educated explicitly the ability to process and actively test hypotheses to a greater degree on a conscious level, but also a significant awareness of executing of the skill under high-risk. This conscious awareness could be theoretically classified as reinvestment and responsible for the significantly inferior performance by explicit groups in comparison to groups via Guided Discovery.

Reinvestment theory (Masters, 1992) proposes that by attracting attention internally to the task, this can overwhelm the attentional processing capacity of working memory, significantly impacting learning. Results from the Movement Specific Reinvestment Scale (MSRS) provide further support. At pre-test (baseline) all five groups showed no significant differences in reinvestment propensity (MSRS) between one another and scored relatively high (in comparison to the less risky sports from the previous study in chapter 3) with scores of low forty. After applying the learning interventions, groups educated via explicit means showed a significant increase in reinvestment. The results from further sub-scales suggest the individuals were now more consciously aware of their movements at both the mechanical and stylistic level (shown in the increased scores from the Conscious Motor Processing and Movement Self-Conscious sub-scales respectively) as a result of the learning intervention. Those in the more implicit-based guided discovery intervention showed no significant change in reinvestment overall (MSRS) along with a minor, yet significant decrease specifically responsible for awareness of movement mechanics (CMP). It should be noted that this lack of impact upon reinvestment is also reflected in comparing reinvestment against the control group who received no tutoring. The control group showed no significant changes in reinvestment throughout testing and was found to show no significant

difference to the Guided discovery interventions. In comparison the Explicit educated were shown to be significantly higher at both testing phases following intervention. The excess reinvestment exhibited by the explicit groups has been shown to disrupt motor production through conscious control using declarative knowledge (Wilson et al, 2007; Mullen et al, 2007; Mullen, Hardy & Tattersall, 2005; Pijpers et al, 2005; Wan & Huon, 2005; Masters & Maxwell, 2004; Hardy, Mullen & Martin, 2001; Masters, Polman & Hammond, 1993).

Performance within a high-risk sporting environment can be easily overwhelming and an ideal state (arousal) is often dictated by the situation (Way, 2012). It was one aim of the current study to examine various learning interventions to assess the effect that propensity to reinvest in beginners whilst performing high-risk sports can influence performance. It can be shown from the results that superior performance can be attained, without impacting on the propensity to reinvest and the potential effect on working memory in a novice sample.

Study 2 was designed to provide insight into the novice stage of learning highlighting only part of the holistic aim intended by this thesis. Investigating a more proficient level of performance where the risk is greater, will allow the potential extent of this implicit effect to be better understood. The next chapter will aim to investigate this effect on the various learning techniques offered at both a heightened level of performance, risk and potential reinvestment.

# Chapter 5

## Experimental Study 3

***“The effect of an Analogy based learning strategy on experienced amateur high-risk sports”***

### 5.1. Introduction

The results from experimental study 2 revealed key characteristics of performance and reinvestment in high-risk sport. It is important to highlight that both the guided discovery and explicit techniques yielded significant improvements in performance overall (pre-retention stages). This was shown in both performance assessment variables; kinematic analysis and subjective observation.

Explicit-based groups suffered a significant decline in performance following the retention phase of the study, but still remained significantly improved overall in testing. This effect was not found from the guided discovery groups who showed no significant difference in performance following the retention phase.

Study 2 revealed no significant differences in performance between live instruction group and their video based counterpart. This lends support to the ongoing argument that both live and video demonstrations are an effective means of delivery at the novice stage of learning. This absence of effect is not shown when explicit and guided discovery counterparts are directly compared to one another. Those educated through means of guided discovery performed

significantly superior against explicitly instructed individuals. This supports the hypothesis that although both forms of instruction were effective at improving performance, the less consciously demanding delivery was more effective with regard to high levels of reinvestment at a novice level.

Reinvestment propensity differed between groups following the training intervention. The explicit instruction groups showed a significant increase in reinvestment in their movements, whilst groups undergoing guided discovery elicited either no change (guided discovery-video) or a significant decrease (guided discovery-live).

All four instruction groups showed an increase in rules recalled, whilst the explicit groups showed significantly more than others. This demonstrates that these four groups are more aware of the movement mechanics on a conscious level, yet guided discovery allowed for this to occur with superior skill acquisition without impacting the propensity to reinvest. This is important to skill acquisition at a more advanced stage of performance, as it will allow the individual to have the required available knowledge for movement modification/development of movement patterns for more advanced skills. The greater risk involved in failing such increasingly difficult movements may not be impacted by a lesser need to reinvest as a result of such implicit education.

Study 2 examined participants in high-risk sports at a novice level performing basic introductory movements, that although are fundamental to the chosen sport of skateboarding, they are simplistic. Study 3 will examine a more experienced sample, performing a more complex movement. The reinvestment tendencies displayed by a more experienced participant were

shown to be greater compared to a novice in study 1. It is one of the aims of this thesis to investigate the impact of reinvestment within high-risk sports at a more advanced level of difficulty and having inherent risk. The participants in this chapter were more experienced and may therefore qualify for a different approach to implicit learning. Many of the core mechanics are understood by this stage which allows the individual to become less dependent on basic declarative knowledge (Ericsson, 2002). This independence allows for a more modern method of implicit learning, known as analogy learning.

Analogies are used to facilitate the learning of a new concept by relating it to a fundamentally similar but possibly unconnected concept (Gentner, Anggoro, & Klibanoff, 2011). This technique is commonly used within coaching across various sports and research. Analogies such as 'kick like a dolphin' have been effective in swimming or 'jump like a rabbit' in skip rope instruction (Tse et al 2017b). Instruction using this technique facilitates the learners' ability to understand the required movement patterns to perform effectively, with minimal explicit instruction (Tse et al 2017a). Research has shown that is an effective method of instruction whereby characteristically, the performance derived from analogy instruction remains robust under psychological stress from anxiety or cognitive demands (Tse et al, 2017a: 2017b; Komar, Chow, Chollet, & Seifert, 2014; Lam et al, 2009a; 2009b; Law, Masters, Bray, Eves, & Bardswell, 2003; Poolton, Masters, & Maxwell, 2007; Liao & Masters, 2001).

The aim of experimental study 3 was to investigate the effects of various skill acquisition techniques, within a high-risk sports population at an advanced level of performance. It was hypothesised that by employing implicit-based



learning interventions, it may lessen the cognitive demand on the athletes. The cognitive demand in a high-risk anxious environment can be substantial, given the increased complexity of the whole body movement and that participants in high-risk sports have a greater propensity to reinvest in their actions. The current study will provide research with an understanding of skill acquisition within experienced individuals at an experienced standard of performance. Given the results from experimental study 1 demonstrating that reinvestment propensity is known to be increased at a more experienced level of performance, the potential beneficial effects of analogy learning could extend beyond novice application as within previous research. Examining this impact both within high-risk sports of an experienced nature and implementing a complex, whole-body movement with the co-ordination of gross motor skills has yet to be examined to date.

## **5.2. Methodology**

### **5.2.1. Participants**

Participants (N=68) were recruited on a voluntary basis through a convenience sampling technique (see table 3 for key demographic data). All participants were required to complete a consent form (see appendix 3, for consent form exemplar) certifying the right to withdraw from the study was available at any point. All participants involved remained naive to the research hypotheses, until the end of final testing phase. All procedures were reviewed and authorised by Teesside University research ethics committee. Participants were randomly

assigned to one of five learning groups; Analogy-Live, Analogy-Video, Explicit-Live, Explicit-Video, and Control.

Group	N	Age (Years)	Experience (Months)
Analogy-Live (ANL)	14	22 ± 3.9	81.3 ± 39.6
Analogy-Video (ANV)	14	21.7 ± 3.1	82.2 ± 27.3
Explicit-Live (EXL)	13	22.5 ± 4	89.4 ± 38.9
Explicit-Video (EXV)	14	21.2 ± 2.3	80.4 ± 28.4
Control	13	20.7 ± 2.8	83.5 ± 34

*Table 3: Key demographic data for all participants in experimental study 3.*

Specific characteristics were required to prevent external factors from potentially confounding the results. Firstly, the participants were required to be of an intermediate stage of learning with 12-60 months of experience, participating within the sport of skateboarding. This classification was based on the opinion of five professional coaches/athletes who had competed on the international stage and are now qualified coaches, authorised by the national governing body. Finally, all participants were to have no previous experience of executing the desired skill 'backside 180° kickflip'. The skill involves a 180 degree body rotation along the longitudinal axis, whilst manipulating the skateboard to follow the body and perform a complete 360 degree rotation along its own sagittal axis. The skill involves controlling one's own body and skateboard both separately and simultaneously, in what is considered a basic manner for the sport (Cole, 2012). The action combines fine motor skills such as spinning and catching the skateboard, controlling the rotation of the performers' body, along with balance, coordination and postural control (Rodriguez, 2017). It is for this reason that the skill was classified as intermediate.

### 5.2.2. Variables

A total of three independent variables were manipulated throughout the testing. The result of these manipulations was then observed, and the behaviour was measured through a total of eleven dependent variables, categorised by; performance, reinvestment, and sensation seeking.

#### 5.2.2.1. Independent Variables

The first independent variable was the delivery of information through demonstration. This demonstration consisted of either an explicit nature or via analogy. The modelling consisted of a 10 minute session, where a professional skateboarder provided verbal coaching points along with visual demonstrations of the skateboarding trick known as a '180° backside kickflip' or commonly known as a 'backside flip' (Rodriguez, 2017). The explicit conditioning of the coaching involved a total of twenty key points regarding the skill (appendix 6). These coaching points have been comprised by the previously mentioned panel of coaches, considering the most effective means of execution. The analogy learning conditions consisted of a single analogical statement "*wind up and tick with your toes*".

The control group received no coaching points, but instead watched footage of the 2011 'X-Games BMX vert' event for the same time periods as the intervention groups' instruction. The control group was segregated at all times of testing to avoid any unfair observational advantages.

The second independent variable was the learning delivery technique to the participants. The demonstrations were conveyed by using either a live model, or by video projection upon an 18ft screen. The video projection was identical

in content to the live demonstration and was shown in real time from a single front view angle (see section 5.2.3. for demonstration overview).

Finally, the variable of time was manipulated throughout testing the participants across three separate time periods; pre, post and retention.

#### 5.2.2.2. Dependent Variables: Performance

Three dependent variables were used to assess the performance aspect of the participants' behaviour. The primary dependent variable was the subjective score based on the execution of the skill via observation. All performances were recorded and played back to a panel of professional athletes, which rated the display of skill. This was on a scale of 1 to 10, whereby ten being superior performance. The study used a single blind approach, as the panel of judges were unaware of the group that the current participant was assigned to. The judges were instructed to compare the perceived performance against their professional opinion of a skilful execution of the skill/trick. This execution of skill was based on factors such as fluidity, height, composure and technique. These guidelines were based on the factors considered by judges during the X-Games championships (Zitzer, 2015).

The second variable used an objective/kinematic approach. This analysed the angle of the skateboard at the peak height of the movement, when the feet come back into contact with the skateboard. The object is to bring the board level at this point, in order to sustain maximum height and stability. Therefore, the lower (and more level) the angle of the skateboard, the better the performance. Board angle was calculated through analysing high speed video footage (60Hz) using the Swinger Athlete software program to calculate peak angle.

Finally, the number of explicit rules formulated was assessed at the end of each testing phase. Explicit rules were classified as any variation or reference to the coaching points which were presented to the individual via the demonstration.

#### 5.2.2.3. Dependent Variables: Reinvestment

The total score of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005), was used to quantify potential reinvestment. Further analysis was conducted using the separate sub-scales of the MSRS known as Conscious Motor Processing (CMP) and Movement Self-Consciousness (MS-C) to identify the nature of potential reinvestment tendencies. Masters et al (2005) reported this scale reliable for both the sub-scales used showing high test-retest reliability (CMP,  $r=0.76$  & MS-C,  $r=0.67$ ) and internal reliability (Cronbach's alpha) (CMP,  $r=0.71$ , & MS-C.  $r=0.78$ ).

#### 5.2.2.4. Dependent Variables: Sensation Seeking

The total score of the Sensation Seeking Scale V (SSSV) (Zuckerman, 1978), was used to quantify sensation seeking. Subsequent analysis was conducted using the four separate sub-scales; Thrill & Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS), and Disinhibition (Dis).

#### 5.2.3. Demonstration

The demonstration was given by a twenty-eight year old male, approximately three metres away from the participant. The task was performed using the apparatus below and was viewed from a side position in order to achieve a clear, holistic view of the target skill including the performer and apparatus. Audio was available by the demonstrator narrating the task as he completed

the movement. This was in accordance with the parameters set by the learning condition. The skill was fully demonstrated approximately twenty times throughout the demonstration. The demonstrator was instructed to follow the same procedure for each of the live demonstrations, as well the single videotaped demonstration. The same videotaped demonstrations were used for both the post and retention testing.

#### 5.2.4. Apparatus

All testing and acquisition phases were conducted at Dynamix skate-park in Gateshead, England. Safety equipment consisted of elbow and knee pads, (TSG) and a helmet (Stateside). This was provided throughout all testing sessions whilst participants completed sessions using their own personal skateboarding equipment.

#### 5.2.5. Procedure

Once all participants had reviewed and completed the participant information sheet providing consent to participate, baseline testing procedures began. The protocol adopted an A-B-A-A design consisting of three tests phases (A) and a single acquisition period (B). The testing phases (pre, post, retention) followed the same protocol consisting of the participant executing ten consecutive executions individually, in their own time. This performance was recorded using a high-speed video-camera, positioned in front of the participant, and played back for subjective and kinematic analyses. The participants completed both the MSRS and SSSV following the completion of the motor performance.

The participants were randomly assigned to each of five groups (see table 3 for group sizes), each of whom were subjected to a different learning

intervention throughout the testing period. There were two analogy learning groups, instructed using demonstrations and a single analogical statement *“wind up and tick with your toes”*. The Analogy-Live group [AN-L] viewed demonstrations from a live model and the Analogy-Video group [AN-V] were educated via the video footage taken prior to protocol. The same was repeated within the Explicit learning for both the Explicit-Live group [EX-L] and the Explicit-Video group [EX-V]. The explicit-based groups received a total of twenty detailed instructions regarding the execution of the skill. This included positioning of arms, centre of gravity etc., along with detailed focus on the co-ordination of their movements. These coaching points were agreed upon by the five coaches involved. Finally, a control group was included which received no tuition throughout the protocol.

Once the initial pre-testing (baseline) testing phase was completed, the acquisition stage began the following week. The acquisition stage lasted a period of four weeks, with two coaching sessions per week. The session began with the presentation of the learning stimuli for a total of ten minutes. The participants then began twenty minutes of motor practice. Following this, the learning stimuli were demonstrated again, followed by a further twenty minutes of practice. This is in accordance with the previous research guidelines (Hebert, 2018; Landers, 1975) for the most effective observational learning to occur. The Control group spent the same period of time viewing footage of the 2011 X-Games competition where no instructions were present or displayed.

Upon completion of the four-week acquisition phase, a post test was immediately conducted. This was the same procedure as the pre-test. This consisted of asking the participants to recall how many of the coaching points

they can remember. This interview was recorded and played back to assess how many rules were recalled in the participants own words.

A retention period of two weeks occurred where no further learning interventions took place. All participants were instructed not to undergo any further practice of the skill in question. At the end of the retention period, a third testing protocol was conducted, following the same procedure as the post-test. This then concluded the procedure and each participant was fully debriefed and provided with contact details for further enquiries. The results were then statistically analysed using the statistical software (SPSS version 22) to assess each of the five groups' scores from the dependent variables listed. The analyses also examined the effect of time from across all three assessment periods.

### **5.3. Results**

Prior to statistical analysis, the data was examined and shown to meet the necessary requirements of normal distribution. Bonferroni adjustments were applied where applicable on post-hoc testing. Results of a two way (3x5) (Time x Group) MANOVA performed on all variables (barring MSRS and SSSV total) confirmed a significant effect for both 'Group', [ $F(36,644.028) = 52.138$ ,  $p < 0.001$ ; Wilks Lambda = 0.007; partial  $\eta^2 = 0.711$ ] and 'Time', [ $F(18,344) = 81.687$ ,  $p < 0.001$ ; Wilks Lambda = 0.039; partial  $\eta^2 = 0.802$ ]. A significant 'Group x Time' interaction was also confirmed, [ $F(72,1036.559) = 13.003$ ,  $p < 0.001$ ; Wilks Lambda = 0.024; partial  $\eta^2 = 0.372$ ].

A separate analysis was conducted on the total scores of the Sensation Seeking Scale V (Zuckerman, 1978) and Movement Specific Reinvestment Scale (Masters et al, 2005), as these variables would be highly correlated to



other variables in the analysis (Tabachnick & Fidell, 2007). A two way (3x5) (Time x Group) MANOVA performed on total scores of the scales used, confirmed a significant effect for 'Group', [ $F(8,376) = 53.310$ ,  $p < 0.001$ ; Wilks Lambda = 0.207; partial  $\eta^2 = 0.545$ ]. A significant effect was confirmed for 'Time', [ $F(4,376) = 30.042$ ,  $p < 0.001$ ; Wilks Lambda = 0.574; partial  $\eta^2 = 0.242$ ], and for the interaction (Group x Time), [ $F(16, 376) = 17.958$ ,  $p < 0.001$ ; Wilks Lambda = 0.321; partial  $\eta^2 = 0.433$ ].

The study again followed a mixed design. The five groups were compared with the respective performance of their group (within), but also against one another (between) during each tested time phase. This concerned all variables tested and have been categorised based on the nature of their focus; performance, reinvestment propensity, or sensation seeking tendency.

#### 5.3.1. Performance Variables

##### Subjective Analysis (SUB): Judges' Score

Figure 16 shows all five groups scored equally during the initial pre-test (baseline) stage. During other testing stages, although all four intervention groups significantly improved their performance, the Analogy-Live and Analogy-Video groups scored highest ranking 1st and 2nd in both the post and retention stages. Analogy learning groups also showed less of a debilitating effect from the retention period.

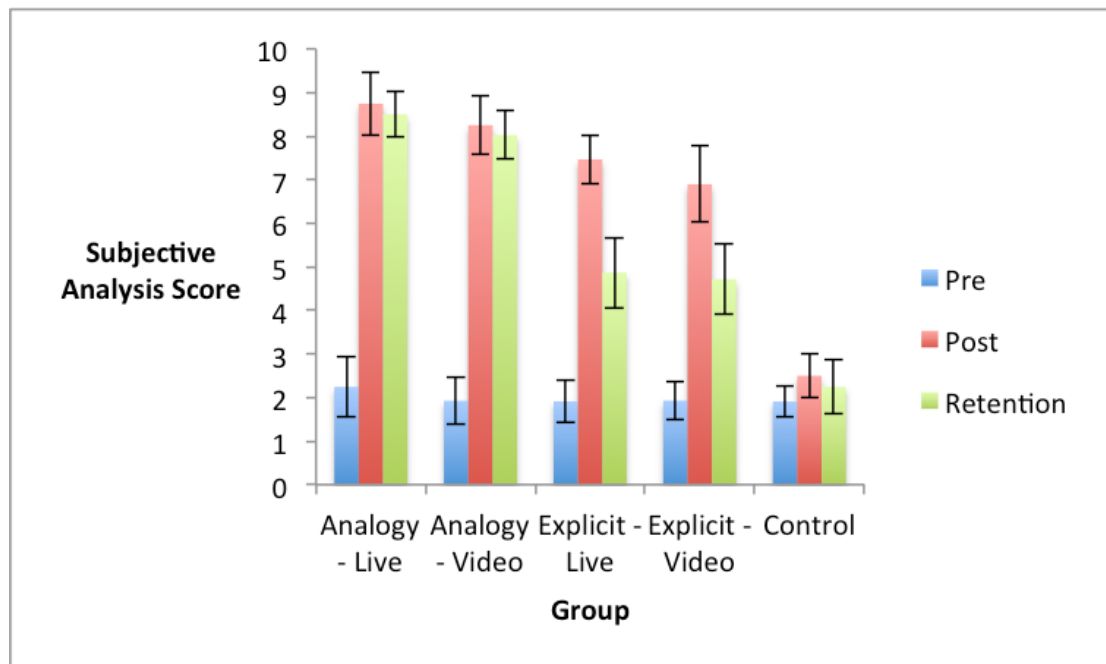


Figure 16. Mean subjective analysis score across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirmed a significant difference within both analogy-based learning groups; Analogy-Live,  $[F(2,26) = 787.4, p < 0.001; \eta^2 = 0.984]$  and Analogy-Video,  $[F(1.250, 6.251) = 360.215, p < 0.001; \eta^2 = 0.977]$ . Pairwise comparisons show that both groups followed the same trends. The performance showed a significant improvement both pre-post and overall, with no significant difference following the retention period (post-retention).

Significant differences were also confirmed in both of the explicit-based groups; Explicit-Live,  $[F(2,24) = 263.818, p < 0.001; \eta^2 = 0.956]$  and Explicit-Video,  $[F(2,26) = 287.09, p < 0.001; \eta^2 = 0.957]$ . Similarly, to the Analogy groups the explicit-based groups showed a significant improvement in performance both pre-post and overall. However, the explicit-based groups suffered a

significant decline in performance following the retention period (post-retention).

Finally, the control group showed a significant effect during testing phases,  $[F(2,24) = 4.304, p < 0.05; \eta^2 = 0.128]$ . Pairwise comparisons revealed that the control group significantly increased their performance pre-post but showed no significant differences in performance overall or following the retention period (post-retention).

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage,  $[F(4,63) = 0.891, ns]$ .

Further analyses confirm significant differences between the groups post acquisition,  $[F(4,63) = 162.7, p < 0.001]$  and following the retention period,  $[F(4,63) = 194.724, p < 0.001]$ . In both cases, identical trends were observed. Pairwise comparisons show that the analogy-based intervention groups performed significantly better than the relative explicit counterpart. No significant differences were identified between respective live and video interventions. The control group performed significantly worse than all other groups.

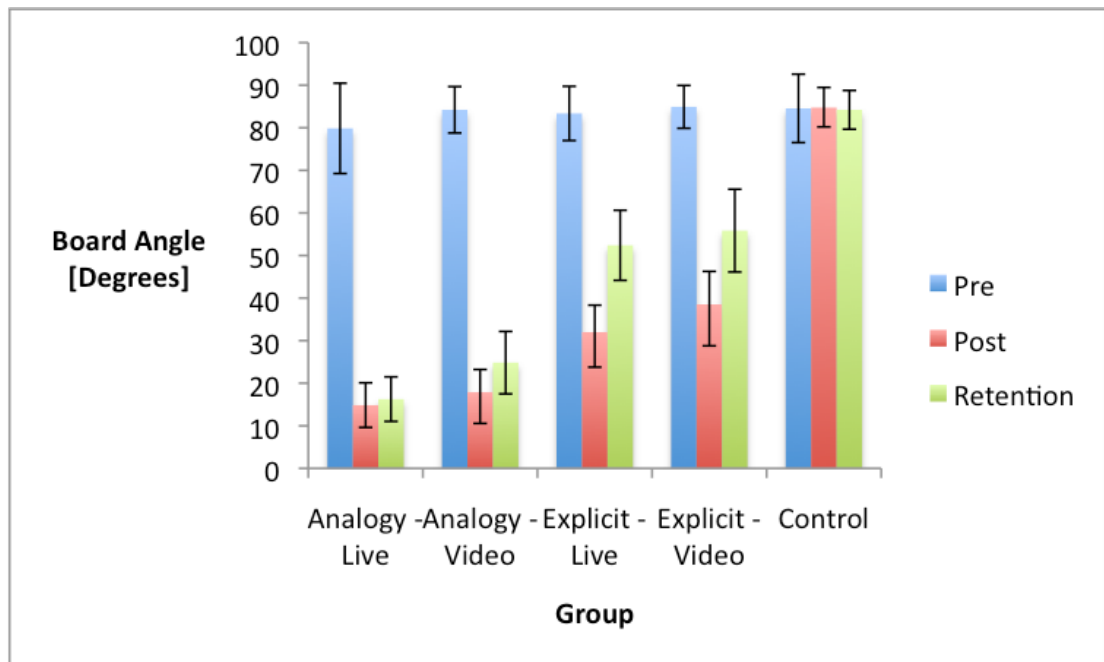
Kinematic Analysis (KIN): Optimal board angle

Figure 17. Mean angle of skateboard at optimal height of skill execution, across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figure 17 shows the average kinematic analysis from the objective review of performance. All groups scored equally during the pre-test (baseline) testing, yet the intervention groups improved their performance whilst the control groups score remained unchanged. Although all intervention based groups significantly improved performance, Analogy-Live showed the best performance, closely followed by Analogy-Video in both post acquisition and retention stages.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirmed a significant difference within the group Analogy-Live, [ $F(2,26) = 526.287$ ,  $p < 0.001$ ;  $\eta^2 = 0.976$ ]. Analysis showed that the group significantly improved their performance pre-post and overall.

The retention period appears not to have effected performance as no significant differences were found post-retention.

Significant differences were confirmed, and identical trends observed by the other three intervention groups; ANV, [ $F(2,26) = 835.226$ ,  $p < 0.001$ ;  $\eta^2 = 0.985$ ], EXL, [ $F(2,24) = 162.961$ ,  $p < 0.001$ ;  $\eta^2 = 0.931$ ] and EXV, [ $F(2,26) = 133.609$ ,  $p < 0.001$ ;  $\eta^2 = 0.911$ ]. All groups showed a significant improvement in performance pre-post and overall. In contrast to the Analogy-Live group, all other intervention groups' performance significantly declined following the retention period (post-retention).

Post-hoc analysis revealed no significant differences within the control group throughout any point in testing, [ $F(1.186, 14.233) = 0.034$ , ns;  $\eta^2 = 0.003$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,63) = 0.305$ , ns].

Analyses confirm significant differences between the groups post acquisition, [ $F(4,63) = 245.271$ ,  $p < 0.001$ ]. Pairwise comparisons show that the analogy-based intervention groups performed significantly better than the relative explicit counterpart. No significant differences were identified between respective live and video interventions. The control group performed significantly worse than all other groups.

Following the retention period, post analyses show the analogy-based groups performed significantly better than the relative explicit counterpart, [ $F(4,63) = 196.916$ ,  $p < 0.001$ ]. The Analogy-Live group performed significantly better than Analogy-Video, but there was no significant difference between explicit groups.

The control group once again scored significantly worse than all other intervention groups.

*Explicit Rules Formulated (RULES)*

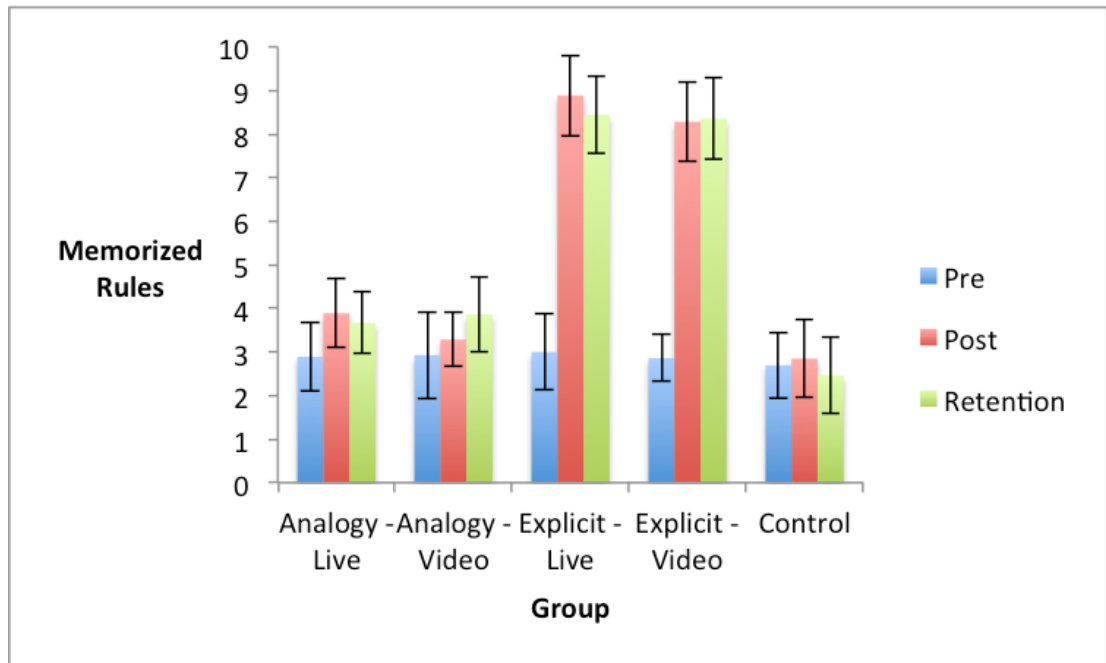


Figure 18. Mean number of explicit rules across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

All groups showed similar prior understanding of the required skill at pre-test (see Figure 18). During the course of testing, the analogy-based groups showed marginal increase in the number of rules recalled. Explicit learning based groups both showed significant increases, with Explicit-Live recalling the most rules of all the groups in both post acquisition and retention. The retention period appears to have affected the 'live' based groups by causing a reduction in recollection, whilst the 'video' based groups actually benefited from it.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirmed a significant effect and similar trends within the groups; ANL [ $F(2,26) = 6.945$ ,  $p < 0.05$ ;  $\eta^2 = 0.348$ ], EXL [ $F(2,24) = 253.2$ ,  $p < 0.001$ ;  $\eta^2 = 0.955$ ] and EXV [ $F(2,26) = 321.051$ ,  $p < 0.001$ ;  $\eta^2 = 0.961$ ]. All three groups showed a significant increase in the number of explicit rules recalled pre-post and overall. No significant differences were found for any of the groups when compared to their relative post-retention data.

Post-hoc analyses confirm no significant differences during any of the testing stages within either the Analogy-Video, [ $F(2,26) = 4.022$ , ns;  $\eta^2 = 0.236$ ], or control, [ $F(2,24) = 0.814$ , ns;  $\eta^2 = 0.064$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,63) = 0.441$ , ns].

Post-hoc analysis showed a significant effect between the groups post acquisition, [ $F(4,63) = 166.155$ ,  $p < 0.001$ ]. Pairwise comparisons show that both Analogy-Live and Analogy-Video recalled significantly less rules than their explicit counterpart. No significant differences were shown between respective live and video groups. The control group showed no significant difference in rules recalled with only the Analogy-Video group. All other groups recalled significantly more rules when compared to the control.

Post-hoc analysis showed a significant effect between the groups after the retention period, [ $F(4,63) = 153.359$ ,  $p < 0.001$ ]. Pairwise comparisons show that both Analogy-Live and Analogy-Video recalled significantly less rules than their explicit counterpart. No significant differences were shown between

respective live and video groups. The control group recalled significantly less rules than all other intervention groups.

### 5.3.2. Reinvestment variables.

#### Movement Specific Reinvestment Scale: Total score (MSRS)

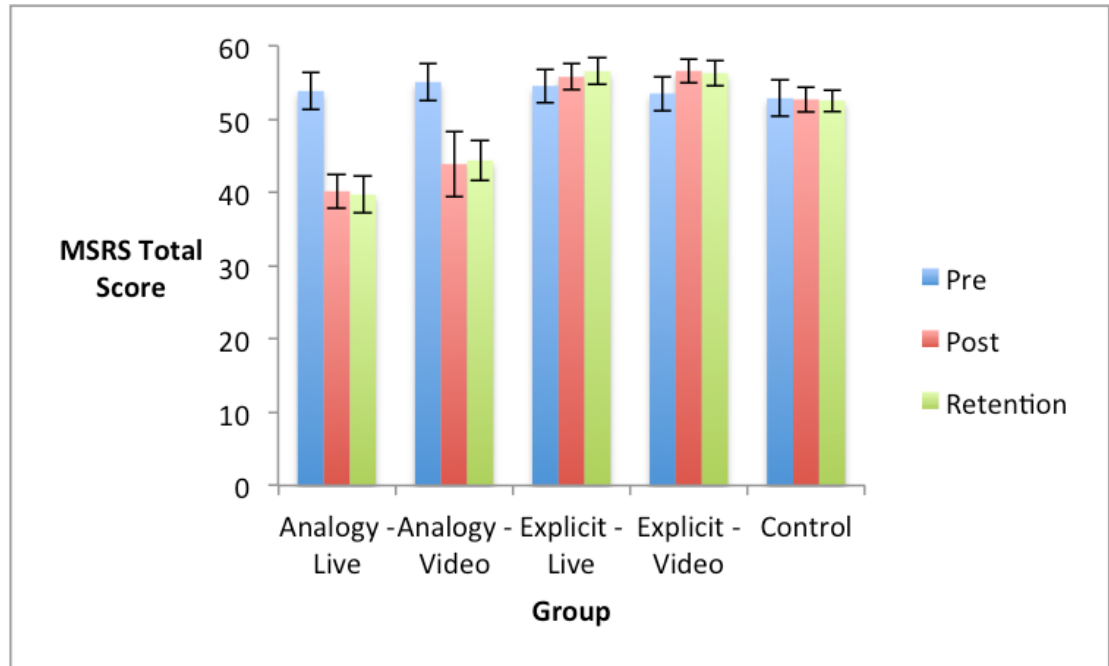


Figure 19. Mean total score of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figure 19, all groups show high scores in reinvestment during the pre-testing stage. Following acquisition the groups educated by analogy, reduced their reinvestment score, with the Analogy-Live group continuing to reduce following the retention period. The explicit-based learning groups showed a continuing increase in reinvestment as testing occurred.

#### *'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm a significant effect within both of the analogy-based learning groups; Analogy-Live,  $[F(1,351, 17.566) = 149.49, p < 0.001; \eta^2 = 0.920]$  and Analogy-Video,  $[F(2,26) = 77.335, p < 0.001; \eta^2 =$



0.856]. Both groups showed a significant decrease in reinvestment score overall and pre-post. No significant differences were found following the retention period (post-retention).

Post-hoc analysis showed a significant change within the Explicit-Video group, [ $F(1.417, 18.424) = 14.413, p < 0.001; \eta^2 = 0.526$ ]. Pairwise comparisons show a significant increase in reinvestment score pre-post and overall, but no significant difference following the retention phase. No significant differences were found within the Explicit-Live group throughout any point in testing, [ $F(2,24) = 2.935, ns; \eta^2 = 0.196$ ].

The control group showed no significant changes in reinvestment score between any of the testing stages, [ $F(2,24) = 0.109, ns; \eta^2 = 0.009$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,63) = 1.763, ns$ ].

Post-hoc analyses confirm a significant effect between groups post acquisition, [ $F(4,63) = 109.359, p < 0.001$ ]. Analyses show that analogy-based groups scored significantly lower than their explicit counterpart. No significant differences were found between the respective live and video based groups. In relation to the control group, the analogy-based groups scored significantly lower, whilst the explicit-based groups scored significantly higher.

Post-hoc analyses conducted on data from the retention stage showed a significant effect, [ $F(4,63) = 175.277, p < 0.001$ ]. Analogy-based groups scored significantly lower than their explicit-based counterpart. No significant differences were found between Explicit-Live and Explicit-Video, however

Analogy-Live scored significantly lower than Analogy-Video. In relation to the control group comparison, the learning strategy used was definitive. Those educated by explicit means scored significantly higher, whilst analogy-based groups scored significantly lower.

Conscious Motor Processing: sub-scale score (CMP)

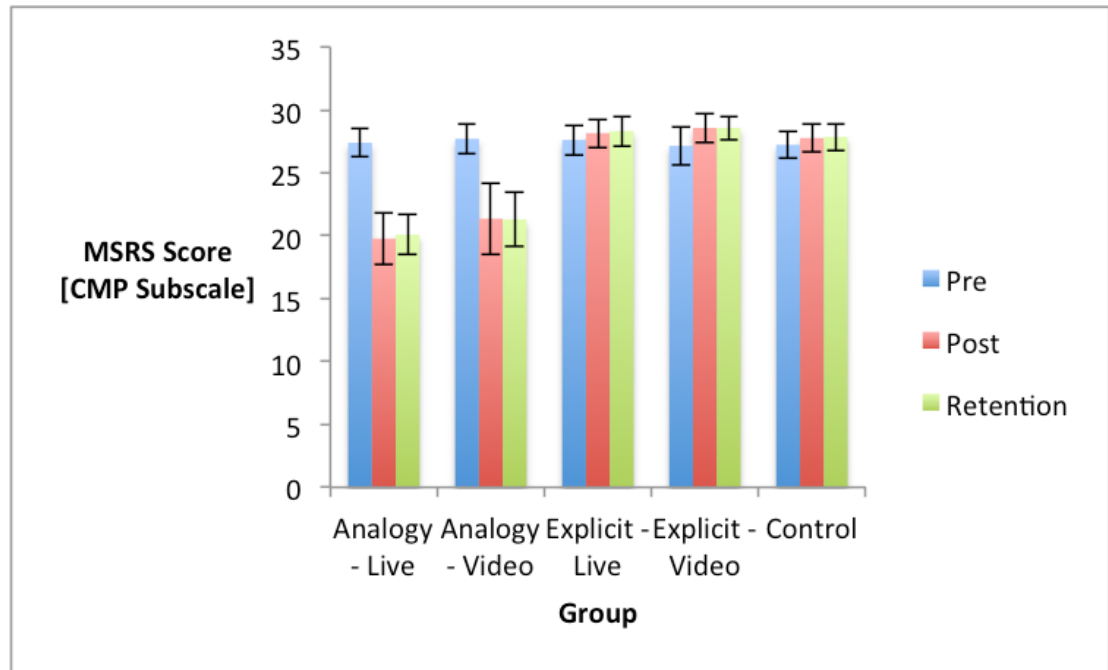


Figure 20. Mean score of the Conscious Motor Processing sub-scale (CMP) of the Movement Specific Reinvestment Scale (MSRS) (Masters et al , 2005) across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figure 20 shows the reinvestment scores concerning the Conscious Motor Processing sub-scale. Similarly, to the MSRS, all groups showed high scores prior to any intervention. Following the acquisition stage, the Analogy-Live and Analogy-Video showed a reduction in reinvestment by almost 30%. Explicit-based groups remained stable, exhibiting high scores throughout testing.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm a significant effect within both of the analogy-based learning groups; Analogy-Live, [ $F(2, 26) = 107.326$ ,  $p < 0.001$ ;  $\eta^2 = 0.892$ ] and Analogy-Video, [ $F(2,26) = 60.583$ ,  $p < 0.001$ ;  $\eta^2 = 0.823$ ]. Both groups showed a significant decrease in reinvestment score overall and pre-post. No significant differences were found following the retention period (post-retention).

Post-hoc analysis show a significant effect within the Explicit-Video group, [ $F(2,26) = 7.222$ ,  $p < 0.05$ ;  $\eta^2 = 0.357$ ]. Analyses confirm a significant increase in reinvestment pre-post and overall, but no significant difference following the retention phase. No significant differences were found within the Explicit-Live group, [ $F(2,24) = 1.128$ , ns;  $\eta^2 = 0.086$ ].

The control group showed no significant changes in reinvestment score between any of the testing stages, [ $F(2,24) = 1.235$ , ns;  $\eta^2 = 0.093$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,63) = 0.564$ , ns].

Post analyses showed a significant and identical trends in both post acquisition, [ $F(4,63) = 76.137$ ,  $p < 0.001$ ] and retention stages, [ $F(4,63) = 114.887$ ,  $p < 0.001$ ]. In both cases, Analogy-based groups again scored significantly lower than the explicit counterpart, whilst no significant differences were found between relative live and video-based groups. No significant differences were between the explicit groups and control. However, the

Analogy-Live and Analogy-Video groups scored significantly lower in comparison to the control.

*Movement Self-Consciousness: sub-scale score (MS-C)*

Figure 21 displays the reinvestment tendencies concerning the MS-C sub-scale scores. All groups showed high scores at pre-test (baseline), but as testing continued the analogy-based groups showed a notable decrease as testing continued, whilst all other groups remained stable. The explicit-live group showed a continual increasing trend, whilst the opposite was evident for analogy-live.

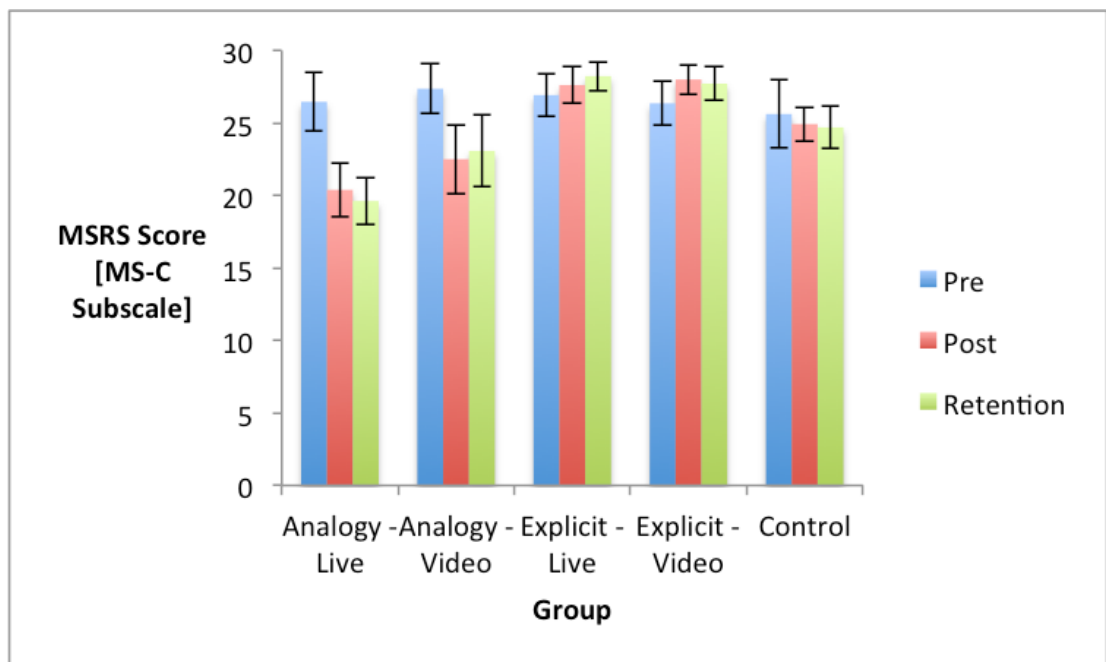


Figure 21. Mean score of the Movement Self-Consciousness sub-scale (MS-C) of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

*'Within Perspective' (pre vs post vs retention)*

Similar trends were found for the analogy-based groups to the other reinvestment related variables. Post-hoc one-way ANOVA showed both

groups to significantly reduce their score between pre and post-acquisition (pre-post); ANL,  $[F(2,26) = 63.138, p < 0.001; ns; n^2 = 0.829]$  & ANV,  $[F(2,26) = 23.321, p < 0.001; ns; n^2 = 0.642]$ .

The Explicit-Video group showed a significant increase pre-post, with no significant differences following the retention period or overall,  $[F(1,1218, 15.833) = 8.648, p < 0.05; n^2 = 0.399]$ .

No significant differences were identified within the Explicit-Live group,  $[F(2,24) = 3.215, ns; n^2 = 0.211]$  or Control,  $[F(2,24) = 1.2, ns; n^2 = 0.091]$ .

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage,  $[F(4,63) = 1.713, ns]$ .

Further post-hoc analyses confirm a significant effect between groups post acquisition,  $[F(4,63) = 54.533, p < 0.001]$ . Analyses show that analogy-based groups scored significantly lower than their explicit counterpart. No significant differences were found between the respective live and video based groups. In relation to the control group, the analogy-based groups scored significantly lower, whilst the explicit-based groups scored significantly higher.

Post-hoc analyses conducted on retention stage showed a significant effect,  $[F(4,63) = 64.866, p < 0.001]$ . Analogy-based groups scored significantly lower than their explicit-based counterpart. No significant differences were found between Explicit-Live and Explicit-Video, however Analogy-Live scored significantly lower than Analogy-Video. In relation to the control group, Analogy-Live scored significantly lower, whilst Analogy-Video showed no

significant difference. Both explicit-based groups scored significantly higher than the control group.

### 5.3.3. Sensation Seeking variables

#### Sensation Seeking Scale V: total score (SSSV)

As can be seen in Figure 22, all groups scored equally high on sensation seeking tendencies. These remained stable throughout testing and this trend was shown for the subsequent sub-scales.

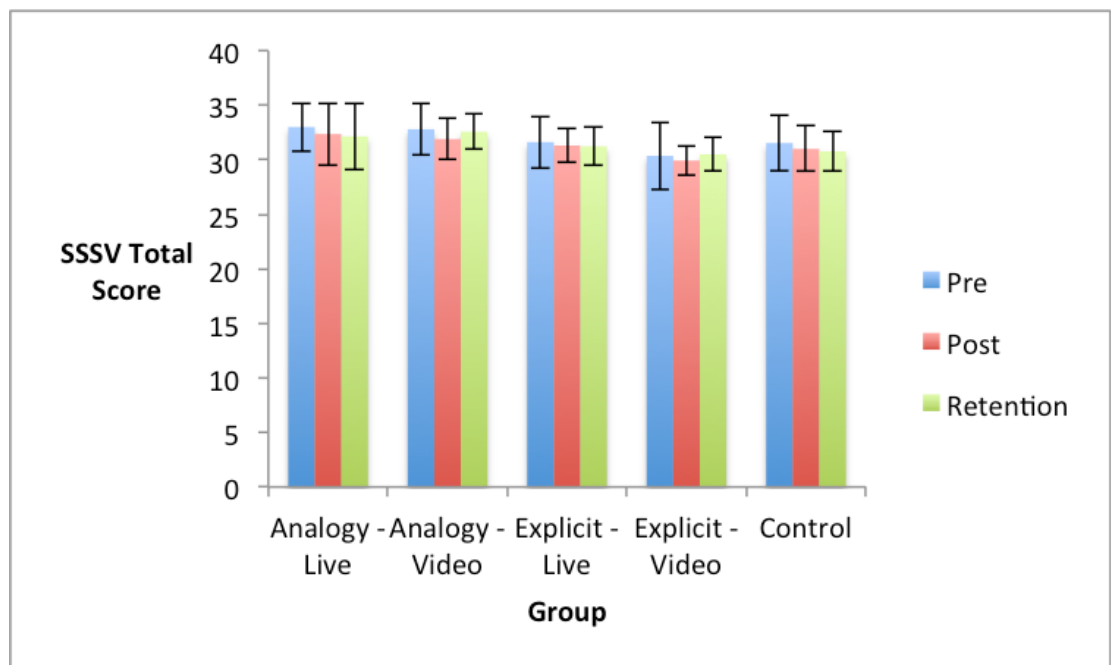


Figure 22. Mean total score for the Sensation Seeking Scale V (SSSV) (Zuckerman, 1978) across all three testing stages in experimental study 3 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

#### *'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live, [ $F(2,26) = 0.656$ , ns;  $\eta^2 = 0.048$ ], Analogy-Video, [ $F(2,26) = 1.295$ , ns;  $\eta^2 = 0.091$ ], Explicit-

Live,  $[F(2,24) = 0.148, ns; n^2 = 0.012]$ , Explicit-Video,  $[F(1.293, 16.806) = 0.293, ns; n^2 = 0.022]$  and control,  $[F(2,24) = 0.5, ns; n^2 = 0.04]$

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirm a significant difference post acquisition,  $[F(4,63) = 2.67, p < 0.05]$ . Pairwise comparisons show that the Analogy-Live group scored significantly higher than Explicit-Video. No significant differences were identified between any other groups.

No significant differences were identified between any of the groups at pretest,  $[F(4,63) = 2.108, ns]$  and following retention  $[F(4,63) = 2.629, ns]$ .

*Thrill & Adventure Seeking: sub-scale score (TAS)*

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live,  $[F(2,26) = 0.176, ns; n^2 = 0.013]$ , Analogy-Video,  $[F(2,26) = 0.255, ns; n^2 = 0.019]$ , Explicit-Live,  $[F(2,24) = 0.112, ns; n^2 = 0.009]$ , Explicit-Video,  $[F(2,26) = 0.37, ns; n^2 = 0.028]$  and control,  $[F(2,24) = 0.778, ns; n^2 = 0.061]$ .

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA revealed no significant differences between any of the groups at any stage of testing; Pre,  $[F(4,63) = 0.45, ns]$ , Post,  $[F(4,63) = 0.73, ns]$  or Retention,  $[F(4,63) = 0.795, ns]$ .

Experience Seeking: sub-scale score (ES)*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live, [ $F(2,26) = 0.039$ , ns;  $\eta^2 = 0.023$ ], Analogy-Video, [ $F(2,26) = 0.308$ , ns;  $\eta^2 = 0.023$ ], Explicit-Live, [ $F(2,24) = 0.188$ , ns;  $\eta^2 = 0.015$ ], Explicit-Video, [ $F(2,26) = 0.141$ , ns;  $\eta^2 = 0.011$ ] and control, [ $F(2,24) = 0.661$ , ns;  $\eta^2 = 0.052$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA revealed no significant differences between any of the groups at any stage of testing; Pre, [ $F(4,63) = 1.253$ , ns], Post, [ $F(4,63) = 1.171$ , ns] or Retention, [ $F(4,63) = 1.024$ , ns].

Boredom Susceptibility: sub-scale score (BS)*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live, [ $F(1.175, 15.273) = 0.301$ , ns;  $\eta^2 = 0.023$ ], Analogy-Video, [ $F(2,26) = 1.492$ , ns;  $\eta^2 = 0.103$ ], Explicit-Live, [ $F(2,24) = 0.042$ , ns;  $\eta^2 = 0.003$ ], Explicit-Video, [ $F(2,26) = 0.923$ , ns;  $\eta^2 = 0.066$ ] and control, [ $F(2,24) = 0.044$ , ns;  $\eta^2 = 0.004$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA revealed no significant differences between any of the groups at any stage of testing; Pre, [ $F(4,63) = 1.216$ , ns], Post, [ $F(4,63) = 1.834$ , ns] or Retention, [ $F(4,63) = 1.831$ , ns].



Disinhibition: sub-scale score (DIS)*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live, [ $F(2,26) = 1.064$ , ns;  $n^2 = 0.076$ ], Analogy-Video, [ $F(1.364, 17.734) = 0.926$ , ns;  $n^2 = 0.067$ ], Explicit-Live, [ $F(2,24) = 0.026$ , ns;  $n^2 = 0.002$ ], Explicit-Video, [ $F(2,26) = 0.157$ , ns;  $n^2 = 0.012$ ] and control, [ $F(1.362, 16.343) = 0.042$ , ns;  $n^2 = 0.003$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirm a significant difference within the pretest, [ $F(4,63) = 3.138$ ,  $p < 0.05$ ] and retention testing data [ $F(4,63) = 3.541$ ,  $p < 0.05$ ]. Pairwise comparisons reveal that the Analogy-Live group scored significantly higher than Explicit-Video. No significant differences were identified between any other groups.

No significant differences were identified between any of the groups post acquisition, [ $F(4,63) = 2.333$ , ns].

**5.4. Discussion**

Firstly, the results of the sensation seeking variables demonstrate that all groups scored highly throughout all testing phases in this personality trait. This lack of change is common as the trait is considered to be stable and the existence supports the notion of all participants being reminiscent of the personality which engages in high-risk sports (Zuckerman, 2007).

Secondly, no differences were found within the control group on any variable throughout testing. This finding was also echoed between the learning interventions as no significant differences were identified comparing live with video counterparts. This supports the claim that both forms of instruction are valid, effective forms of education.

The results from the analyses identify key differences regarding learning strategy, highlighting differences in performance and reinvestment propensity. Similar to the previous chapter, significant improvements in performance were made overall by all learning conditions with the exception of the control group.

When comparing the analogy and explicit groups directly, the analogy intervention resulted in several key behaviours. Firstly, the analogy-based learning interventions (Analogy-Live & Analogy-Video) produced significantly superior performance both immediately after and following two week post intervention. The two-week retention period was shown to be significantly detrimental to those educated via explicit means only. The performance derived by the analogy intervention was found to be robust and showed no significant change in score following the retention period.

These behaviours may be justified using the theoretical arguments proposed earlier in chapter two. The notion of overwhelming working memory capacity can be supported by the inferior performance measures, combined with the results from the consciously recalled rules and movement reinvestment scores. All of the learning interventions resulted in a significant increase in conscious awareness of coaching points compared to baseline measures. This is expected, as pre-acquisition testing (baseline) measures showed limited understanding of the novel task, therefore a basic

understanding of the task could be considered a minimal improvement. Analogy learning is not designed to inhibit conscious awareness but simply limit the amount of declarative knowledge available for processing (Masters et al, 2008). Given that these participants are of a higher learning calibre, it is understandable that a degree of conscious awareness is possible when questioned. As mentioned earlier, the concept is to limit awareness of declarative knowledge to remain within a tolerable degree for working memory. Although all four interventions showed an improvement in performance, the analogy interventions recalled significantly less rules, whilst showing superior performance in comparison.

Similar to the previous study, reinvestment may be the conceptual root of the problem. Reinvestment theory attributes this overwhelming effect on working memory and subsequent performance to a conscious inward focus of attention. Pre-acquisition testing (baseline) measures of movement specific reinvestment confirm all five experimental groups to exhibit an exceptionally high propensity to reinvest (scores of fifty out of potential sixty). Upon applying the interventions, reinvestment scores from participants educated via analogy reduced significantly (approx. 20%). The opposite effect was evident by the explicit intervention. Whilst performance significantly declined, the reinvestment scores either significantly increased or remained at their heightened baseline measure. These findings are in part, in agreement with previous research whereby increased levels of reinvestment have been recorded alongside failure in performance (Tse et al, 2017a;2017b; Tzetzis & Lola, 2015; Lam et al, 2009a; 2009b; Masters et al, 2008a; Poolton et al, 2007b; Liao & Masters, 2001).

This inverse effect of reinvestment and performance was identified in the last study, involving novice participants. The same theoretical justification by the Attentional control theory (Eysenck et al, 2007) and is also applicable for this data set. Conversely, the potential for fear based bias may be more applicable based on the heightened risk, technicality, and advanced understanding of the sport held by the sample.

Attentional bias theory (Williams et al, 1997, 1988) argues that this bias is primarily involuntary in nature and is triggered by both external environmental cues or internally, as a result of past memories or intrusive thoughts (Baddeley, 2007). This bias is based on the principle that attention is directed to the fearful stimuli, enhancing the shifting function whilst hindering the inhibition functions of the central executive (Fox et al, 2001; Fox, 1994). Fear has been discussed in chapter two as responsible for successfully monopolising attentional processes from a variety of forms (Gremsl et al, 2018; Duval et al, 2018; Amir et al, 2009; Mogg, et al, 2004; Hope et al, 1990; Watts et al, 1986; Williams & Broadent, 1986; Mathews & McLeod, 1985). The fearful stimuli in current study could arguably be fear of physical risk. Research has found that fear of physical harm can directly influence the tendency to reinvest within movements designed to avoid injury (Orrell et al, 2009; Wong et al, 2008; Masters et al, 2007). Given the high-risk nature of sports such as skateboarding, successful performance is the most effective means of achieving this. Therefore, focusing on the schema of the target skill can create an attentional bias given the inherent anxiety resulting from failure.

The findings of study 3 illustrate an argument for less conscious awareness to successfully acquire and perform in a high-risk sport. This notion was initially presented at a novice level in the previous chapter and is now shown to be

evident at a more advanced stage of performance, risk and learning. Ford et al (2005) implied that specifically identifying where reinvestment affects along the learning spectrum is difficult to ascertain. Reinvestment theory can only provide that the movement must be automated partially at a minimum (Masters & Maxwell, 2008) supporting the results found from the previous two studies. Research in the field of high-risk sports remains limited and research into reinvestment tendencies in professional athletes is less still.

By examining the effect of reinvestment and learning interventions relating to them at the highest level, it would provide original contribution to the field. At a professional level the risk, skill, complexity and inherent emotion associated is at the highest. The potential benefits of examining practice interventions are warranted to ascertain if the effect occurs throughout the learning spectrum. The results from experimental study 1 outlined in chapter 3, exhibit that reinvestment propensity is most elevated at the highest stage of performance and learning. The results for the current study have shown that implicit-based learning strategies can be inherently effective at performing whole-body complex movements under stress from physical threat. This notion has yet to be examined empirically in research as this is an original concept. The notion extends further within professional capacity. Given that results from experimental study 1 demonstrate the highest propensity of reinvestment stems from a professional population, it would warrant exploring if any further original contribution of knowledge can be ascertained.

# Chapter 6

## Experimental Study 4

*“The effect of an Analogy based learning strategy in professional high-risk sports”*

### 6.1 Introduction

The previous two studies have shown similar trends regarding reinvestment and skill acquisition in high-risk sports. In chapter 4, the results showed not only better performance elicited under implicit instruction, it also limited the accumulation of declarative knowledge. This in turn limited the propensity to reinvest within the performed skill. From chapter 5, results on a more advanced sample found a similar effect. Not only was better performance measured, the use of analogy learning had a reductive overall effect from baseline. This implies that not only can implicit-based instruction provide a reduced, reinvested learning environment, but also lower the preconceived reinvestment propensity of a particular skill in high-risk sports participation.

Coaching from both an analogy and explicit-based perspective was shown to be effective as significant overall improvements in performance were observed. The control group showed no improvement in performance overall maintaining the validity of the research design.

When directly compared to one another, the analogy intervention showed significant superior performance in both post-instruction and retention phases. No support could be found for preference in the debate of live versus video

demonstration as no significant differences were found between the two methods of delivery.

These patterns of effect were reflected in the reinvestment activity measured. Reinvestment altered between intervention groups, whilst the control showed no change throughout testing, suggesting any differences are a result of the learning intervention. Analogy-based groups showed a significant reduction in reinvestment throughout testing. The opposite effect was shown by the explicitly instructed, demonstrating significant increases in previously heightened scores. When comparing these two approaches, analogy instruction yielded significantly lower reinvestment behaviour compared to explicitly instructed groups. Reinvestment from analogy learning was also shown to be lower than the control group, where initially no differences were observed.

Analogy-based instructions significantly reduced reinvestment propensity accumulated less declarative knowledge and yielded superior performance. This reductive effect has been amplified between an increasing complexity and skill level within amateur performance during chapters 4 and 5. Initially, reinvestment in analogy instructed individuals were shown to be reduced in comparison to explicit, whilst chapter 5 revealed this reduction could be magnified to below baseline levels in a more advanced skill level and heightened risk. The following study will examine this effect in an even more advanced (in terms of skill level), professional population whereby the complexity and inherent risk levels are at their highest.

Research regarding learning within expert or professional performance of high-risk sports is very limited. Developing learning within expert

performance has been evaluated showing both great domain specificity and diversity (Ericsson, 2002). The training in these areas is designed to aid guiding the performer to develop their own solution through reflective self-evaluation and problem solving (Ericsson, 2002). The individual differences and subsequent diversity are considered key concepts in developing expert performance and preparation for expert performers to develop beyond the accumulated knowledge previously held.

Despite the existence of such an individualistic approach to expert learning, three generalisable characteristics can be seen (Ericsson, 2002). Firstly, the target goals to be attained must be specific to the setting in order to facilitate changes in behaviour and performance (Locke & Latham, 1984). Secondly, learning should be mindful and reflective with a focus on genuine understanding (Langer, 1997). Finally, learning should be optimised by designing and monitoring their activity and performance (Schunk & Zimmerman, 1994). A common trait between these characteristics is the degree by which the learner must become self-reflective regarding their own learning. These characteristics outline a self-aware approach towards the target goal behaviour in order to achieve expert performance. Coupling this with evidence regarding stress induced reinvestment, performing within high-risk sports could create an even greater inward focus regarding the aspects of motor control.

Traditional theories of skill acquisition (Anderson, 1982; 1987; Fitts & Posner, 1967) propose a movement toward automaticity in order to master a skill (Ericsson, 2002). Expert performance continues to improve as a function of increasing experience and deliberate practice, whilst attempting to avoid the arrested development of automaticity. Expert athletes have been known to



counteract this arrested development by retaining cognitive control via self-reflection through deliberately acquiring and refining cognitive mechanics (Ericsson, 2002). This can be accomplished by comparing mental representations of one's own behaviour to another more proficient individual or with past successful performance (Ericsson & Lehmann, 1996; Lehmann & Ericsson, 1995; 1997). Research suggests that through these mental comparative representations the performer can alter and modify their performance to adapt to different constraints (Lehmann & Ericsson, 1997; 1995). This research supports the three stages outlined by Bloom (1985) relating to the development of learning in support of a teacher. At the latter stage the performer is able to independently monitor their performance and develop complex mental representations for parallel comparison (Ericsson, 1996; Glaser, 1996). Following this a fourth stage (Creativity) was proposed by Ericsson (2002) whereby the individual creates new variations on knowledge possessed. This creative expansion on declarative knowledge in a specific domain is renowned to represent the supreme level of expertise (Ericsson, 2002).

Research has indirectly examined the reinvestment tendencies of experienced athletes, in relation to predicting performance under pressure with other psychological measures. Iwatsuki & Wright (2016) examined the movement specific reinvestment of National Collegiate Athletic Association Division 3 athletes in both individual and team sports. The scores obtained from this study showed athletes performing at a semi-professional level scoring an average of 41.1 and 38.4 of potential 60 on MSRS regarding individual and team sports respectively. This is similar of Guekes et al (2017), whereby expert basketball players of more than a decade produced scores of 43.19 on the MSRS. This

evidence supports that even though these athletes are regarded as expert within their field, there is still a degree of conscious reflection on their movements. It should be noted that the sports within these studies are basketball, tennis, squash, soccer and volleyball; all of which are classified as medium-low risk by Zuckerman (2007). Despite this trait being present at an experienced level, it should also be considered that average scores of 40 on the MSRS pale in comparison to measures of 58 and even maximum 60 obtained in study 1 of this thesis when examining expert high-risk athletes. To date no known research has examined the reinvestment propensity of expert athletes in high-risk sports. The results from study 1 confirm that the expert athletes in high-risk sports, reinvest more so than less experienced high-risk athletes, and low-risk sports from novice through to professional. Research has shown that professionals can consciously reflect upon their movements, within a low-risk setting. As the element of risk is demonstrating more influence to conscious control of movement throughout this thesis, examining professionals performing under high-risk could warrant further understanding.

The current study aims at exploring the acquisition of skills at the highest level in high-risk sports, whereby risk and complexity are amplified. Given the findings throughout the last several chapters, performance and reinvestment can be influenced by the coaching technique employed (Explicit or Implicit). Research has shown that expert performers continually self-reflect as a requirement of their performance level (Ericsson, 2002). This internal focus on performance is characteristically similar to reinvestment, whereby the mechanics of the movement are analysed. Exploring their effectiveness at the highest risk, complexity and performance level is crucial as implicit-based coaching is known to remain robust under stress (Tse et al, 2017a; 2017b;

Tzetzis & Lola, 2015; Lam et al, 2009a; 2009b; Masters et al, 2008a; 2008b; Gucciardi & Dimmock, 2008; Poolton et al, 2007b; Liao & Masters, 2001). This will provide a holistic view towards the interaction between reinvestment and performance in high-risk sports.

## 6.2 Methodology

### 6.2.1. Participants

Participants (N=43) were recruited on a voluntary basis through a convenience sampling technique (see table 4 for key demographic data). All participants were required to complete a consent form (see appendix 3, for consent form exemplar) certifying the right to withdraw from the study was available at any point. All participants involved remained naive to the research hypotheses, until the end of final testing phase. All procedures were reviewed and authorised by Teesside University research ethics committee. Participants were randomly assigned to one of five learning groups; Analogy-Live, Analogy-Video, Explicit-Live, Explicit-Video, and Control.

Group	N	Age (Years)	Experience (Months)
Analogy-Live (ANL)	9	26.4 ± 5.1	207.9 ± 59.9
Analogy-Video (ANV)	9	24.2 ± 5.3	183 ± 61.9
Explicit-Live (EXL)	9	24.9 ± 5.2	199.1 ± 75.6
Explicit-Video (EXV)	9	27.4 ± 3.2	216.1 ± 45.7
Control	7	26.1 ± 5.1	193.1 ± 38.1

Table 4: Key demographic data for all participants in experimental study 4.

Specific characteristics were required to prevent external factors from confounding the results. Firstly, the participants were required to be professional athletes within the sport of skateboarding. This was defined as

someone who engages in an activity as their means of livelihood (Kent, 2006), including competitive success and sponsorship. Secondly, all participants were to have no previous experience of executing the desired skill '180° nollie w/backside 360° heelflip' or more commonly known in the sport as a 'backside nollie laserflip'. The skill involves a 180° body rotation along the longitudinal axis. Additionally, the performer must manipulate the skateboard to follow the body and perform a complete 360 degree rotation along its own sagittal axis and longitudinal axis simultaneously. The skill involves the athlete controlling their own body and skateboard both separately and simultaneously, in what is considered an advanced manoeuvre for the sport. This particular skill also requires the person to perform the skill on the nose (front) of the skateboard, which is contrary to standard performance thus, increasing the difficulty. This alteration is considered a more advanced skill, due to the unfamiliarity and additional balance, coordination and composure required, (Cole, 2012). It is for this reason that the skill was classified as expert from the panel of coaches involved.

### 6.2.2. Variables

A total of three independent variables were manipulated throughout the testing. The result of these manipulations was then observed, and the behaviour was measured through a total of eleven dependent variables, categorised by; performance, reinvestment, and sensation seeking.

#### 6.2.2.1. Independent Variables

The first independent variable was the delivery of information through demonstration. This demonstration consisted of either an explicit nature or via an analogy. The modelling consisted of a 10 minute session, where a

professional skateboarder provided verbal coaching points along with visual demonstrations of the skateboarding trick known as a 'backside nollie laserflip'. The explicit conditioning of the coaching involved a total of twenty key points regarding the skill. These coaching points have been comprised by the previously mentioned panel of coaches, considering the most effective means of execution. The analogy learning conditions consisted of a single analogical statement "*circle with front heel, tick with back heel*".

The control group received no coaching points, but instead watched footage of the 2012 'X-Games BMX street' event for the same time periods as the intervention groups' instruction. The control group was segregated at all times of testing to avoid any unfair observational advantages.

The second independent variable was the learning delivery technique to the participants. The demonstrations were conveyed by using either a live model, or by video projection upon an 18ft screen. The video projection was identical in content to the live demonstration and was shown in real time from a single front view angle (see section 6.2.3. for demonstration overview).

Finally, the variable of time was manipulated throughout, testing the participants across three separate time periods; pre, post and retention.

#### 6.2.2.2. Dependent Variables: Performance

Three dependent variables were used to assess the performance aspect of the participants' behaviour. The primary dependent variable was the subjective score based on the execution of the skill via observation. All performances were recorded and played back to a panel of professional

athletes, which rated the display of skill. This was on a scale of 1 to 10, with ten being superior performance. The study used a single blind approach, as the panel of judges were unaware of the group that the current participant was assigned to. The judges were instructed to compare the perceived performance against their professional opinion of a skilful execution of the skill/trick. This execution of skill was based on factors such as fluidity, height, composure and technique. These guidelines were based on the factors considered by judges during the X-Games championships (Zitzer, 2015).

The second variable used an objective/kinematic approach. This analysed the angle of the skateboard at the peak height of the movement, when both feet come back into contact with the skateboard. The object is to bring the board level at this point, in order to sustain maximum height and stability. Therefore, the lower the angle of the skateboard, the better the performance. Board angle was calculated through analysing high speed video footage (60Hz) using the Swinger Athlete software program to calculate angle at peak height. Finally, the number of explicit rules formulated was assessed at the end of each testing phase. Explicit rules were classified as any variation or reference to the coaching points which were presented to the individual via the demonstration.

#### 6.2.2.3. Dependent Variables: Reinvestment

The total score of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005), was used to quantify potential reinvestment in the sporting samples. Further analysis was conducted using the separate subscales of the MSRS known as Conscious Motor Processing (CMP) and

Movement Self-Consciousness (MS-C) to identify the nature of potential reinvestment tendencies. Masters et al (2005) reported this scale reliable for both the sub-scales used showing high test-retest reliability (CMP,  $r=0.76$  & MS-C,  $r=0.67$ ) and internal reliability (Cronbach's alpha) (CMP,  $r=0.71$ , & MS-C,  $r=0.78$ ).

#### 6.2.2.4. Dependent Variables: Sensation Seeking

The total score of the Sensation Seeking Scale V (SSSV) (Zuckerman, 1978), was used to quantify sensation seeking. Subsequent analysis was conducted using the four separate sub-scales; Thrill & Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS), and Disinhibition (Dis).

#### 6.2.3. Demonstration

The demonstration was given by a twenty-eight year old male, approximately 3 three metres away from the participant. The task was performed using the apparatus listed below and was viewed from a side position in order to achieve a clear, holistic view of the target skill. Audio was available by the demonstrator narrating the task as he completed the movement. This was in accordance with the parameters set by the learning condition. The skill was fully demonstrated approximately twenty times throughout the demonstration. The demonstrator was instructed to follow the same procedure for each of the live demonstrations, as well the single videotaped demonstration. The same videotaped demonstrations were used for both the post and retention testing.

#### 6.2.4. Apparatus

All testing and acquisition phases were conducted at Dynamix skatepark in Gateshead, England. All video recording was performed using an Olympus i-Speed 2 high speed camcorder and kinematic analysis was carried out using Swinger software. Safety equipment consisted of elbow and knee pads, (TSG) and a helmet (Stateside). This was provided throughout all testing sessions whilst participants completed sessions using their own personal skateboarding equipment.

#### 6.2.5. Procedure

Once all participants had reviewed and completed the participant information sheet, providing consent to participate, baseline testing procedures began. The protocol adopted an A-B-A-A design which will consist of three tests phases (A) and a single acquisition period (B). The testing phases (pre, post, retention) followed the same protocol consisting of the participant executing ten consecutive executions individually, within their own time. This performance was recorded using a high speed video-camera, positioned in front of the participant, and played back for subjective and kinematic analyses. The participants completed both the Movement Specific Reinvestment Scale (MSRS) and Sensation Seeking Scale (SSSV) following the completion of the motor performance.

The participants were randomly assigned to each of five groups (see table 4 for group sizes), each of whom were subjected to a different learning intervention throughout the testing period. There were two analogy learning groups instructed using demonstrations with a single analogical statement



*“draw a circle with the front heel, tick with the back heel”*. The Analogy-Live group [AN-L] viewed demonstrations from a live model and the Analogy-Video group [AN-V] were educated via the video footage taken prior to protocol. The same was repeated within the Explicit learning for both the Explicit-Live group [EX-L] and the Explicit-Video group [EX-V]. The explicit-based groups received a total of twenty detailed instructions regarding the execution of the skill. This included positioning of arms, centre of gravity, etc., along with detailed focus on the co-ordination of their movements. These coaching points were agreed upon by the five coaches involved. Finally, a control was included which received no tuition throughout the protocol.

Once the initial baseline testing phase was completed, the acquisition stage began the following week. The acquisition stage lasted a period of two weeks, with four coaching sessions per week. The session began with the presentation of the learning stimuli for a total of ten minutes, the participants then began twenty minutes of motor practice. Following this, the learning stimuli were demonstrated again, followed by a further twenty minutes of practice. This is in accordance with the guidelines of Landers (1975) for the most effective observational learning to occur. The Control group spent the same period of time viewing footage of the 2011 X-Games competition where no instructions were present or displayed.

Upon completion of the two-week acquisition phase, a post test was immediately conducted. This was the same procedure as the pre-test. This consisted of asking the participants to recall how many of the coaching points they can remember. This interview was recorded and played back to assess how many rules were recalled in the participants own words.

A retention period of two weeks occurred where no further learning interventions took place. All participants were instructed not to undergo any further practice of the skill in question. At the end of the retention period, a third testing protocol was conducted, following the same procedure as the post-test. This then concluded the procedure and each participant was fully debriefed and provided with contact details for further enquiries. The results were then statistically analysed using the statistical software (SPSS version 22) to assess scores of the five groups from the dependent variables listed. The analyses also examined the effect of time from across all three assessment periods.

### 6.3 Results

All data was examined and shown to meet the necessary assumptions of parametric analysis. Bonferroni adjustments were applied where applicable on post-hoc testing. Results of two way (3x5) (Time x Group) MANOVA performed on all variables (barring MSRS and SSSV total) confirmed a significant effect for both 'Group', [ $F(36,398.068) = 20.362, p < 0.001$ ; Wilks Lambda = 0.02; partial  $\eta^2 = 0.623$ ] and 'Time', [ $F(18,212) = 64.022, p < 0.001$ ; Wilks Lambda = 0.024; partial  $\eta^2 = 0.845$ ]. A significant 'Group x Time' interaction was also confirmed, [ $F(72,652.352) = 6.474, p < 0.001$ ; Wilks Lambda = 0.038; partial  $\eta^2 = 0.366$ ].

A separate analysis was conducted on the total scores of the Sensation Seeking Scale V (Zuckerman, 1978) and Movement Specific Reinvestment Scale (Masters et al, 2005), as these variables would be highly correlated to other variables in the analysis (Tabachnick & Fidell, 2007). A two way (3x5)

(Time x Group) MANOVA performed on total scores of the scales used, confirmed a significant effect for 'Group', [ $F(8,226) = 23.311$ ,  $p < 0.001$ ; Wilks Lambda = 0.3; partial  $\eta^2 = 0.452$ ]. A significant effect was confirmed for 'Time', [ $F(4,226) = 16.678$ ,  $p < 0.001$ ; Wilks Lambda = 0.596; partial  $\eta^2 = 0.228$ ], and for the interaction (Group x Time), [ $F(16,226) = 7.799$ ,  $p < 0.001$ ; Wilks Lambda = 0.557; partial  $\eta^2 = 0.254$ ].

The study again followed a mixed design. The five groups were compared against the respective performance of their own group (within), but also against one another (between) during each tested time phase. This concerned all variables tested and have been categorised based on the nature of their focus; performance, reinvestment propensity, or sensation seeking tendency.

### 6.3.1. Performance Variables

#### Subjective Analysis (SUB): Judges' Score

Figure 23 shows all groups scored equally lowly at pretesting and showed an increase in performance as testing continued. Although all intervention based groups showed a significant increase in performance score, the Analogy-Live showed the best performance in both the post-testing and after the retention period was applied. This was a ~15% better performance than the next leading performance. The retention period can be seen to

significantly hinder performance in both the Explicit-Live and Explicit-Video groups but show only a marginal effect on the analogy-based groups.

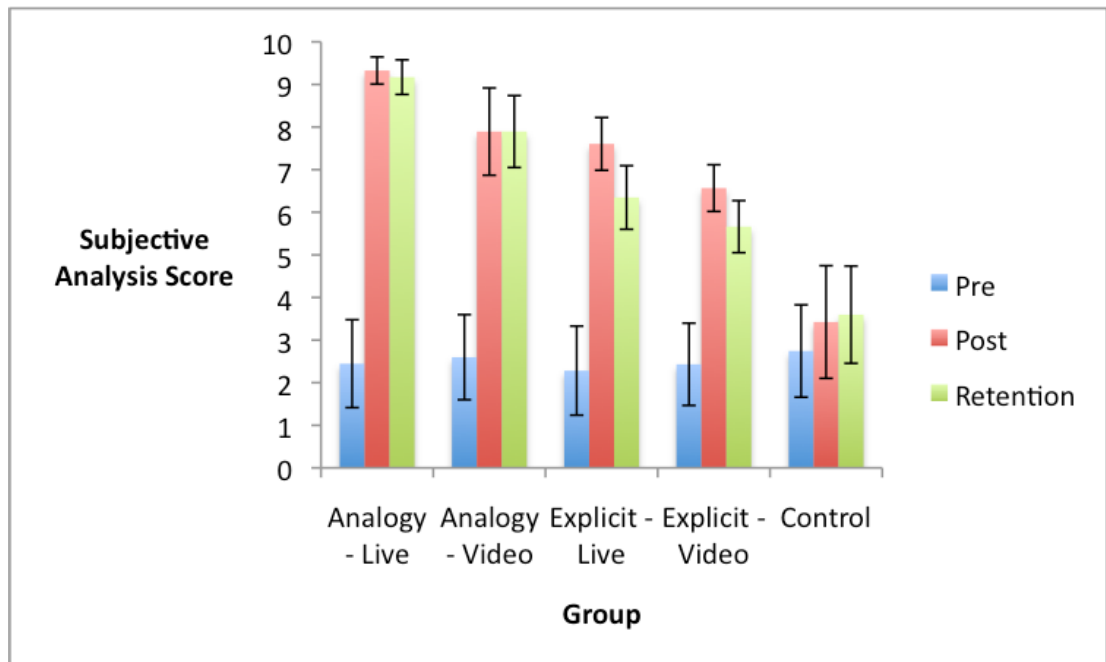


Figure 23. Mean subjective analysis score across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm a significant improvement in performance following acquisition (pre-post acquisition), and overall (pre-acquisition and retention) for both Analogy-Live [ $F(1,22,9.756) = 264.774$ ,  $p < 0.001$ ;  $\eta^2 = 0.971$ ], and Analogy-Video [ $F(2,16) = 405.603$ ,  $p < 0.001$ ;  $\eta^2 = 0.981$ ]. No significant differences were identified between post and retention stages.

The Explicit groups showed the same significant improvement in performance, post-acquisition and overall but suffered a significant decline in performance following the retention stage, [Explicit-Live,  $F(2,16) = 155.109$ ,  $p < 0.001$ ;  $\eta^2 = 0.951$ ], [Explicit-Video,  $F(2,16) = 114.93$ ,  $p < 0.001$ ;  $\eta^2 = 0.935$ ].

No significant differences were found between any of the testing stages for the control group, [ $F(2,12) = 5.707$ , ns;  $\eta^2 = 0.487$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,42) = 0.236$ , ns].

Following the acquisition period, post-hoc analysis showed that the Analogy-Live and Analogy-Video performed significantly better than Explicit-Live and Explicit-Video, [ $F(4,42) = 56.533$ ,  $p < 0.001$ ]. Analogy-Live and Explicit-Live scored significantly higher than their video educated counterparts. All intervention-based groups scored significantly higher than the control group.

Post-hoc analyses conducted following the retention stage, showed that the analogy-based groups performed significantly better the respective explicit group [ $F(4,42) = 62.314$ ,  $p < 0.001$ ]. No significant differences were found between Explicit-Live and Explicit-Video, however the Analogy-Live groups performed significantly better than Analogy-Video. All intervention-based groups scored significantly higher than the control group.

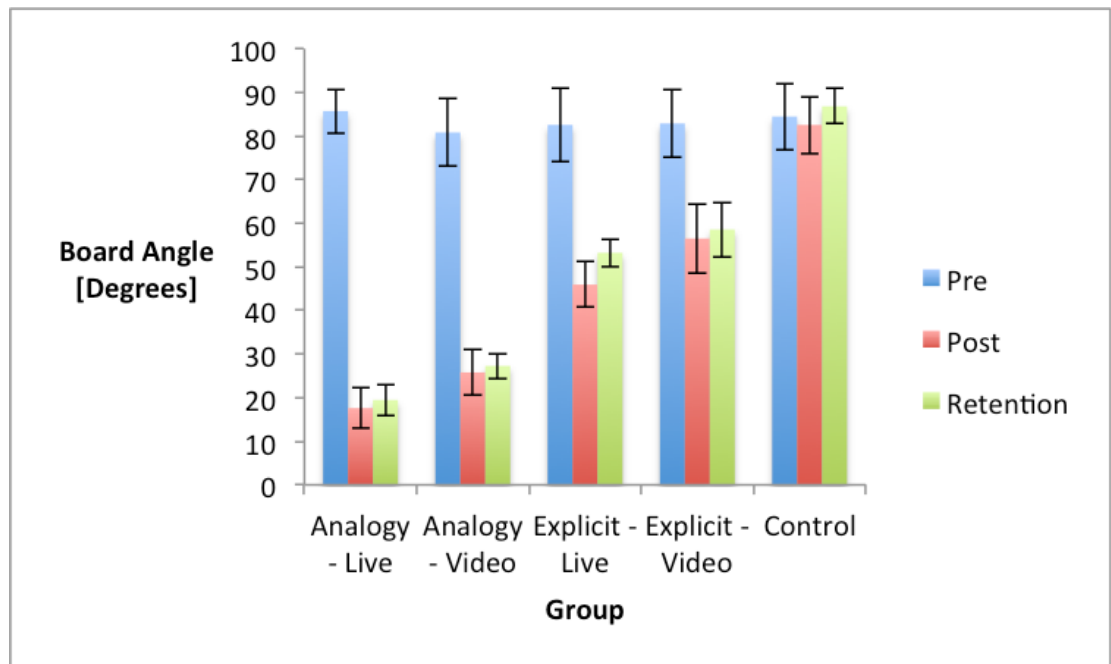
Kinematic Analysis (KIN): Optimal board angle

Figure 24. Mean angle of skateboard at optimal height of skill execution, across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figure 24 shows the performance of all groups tested from the kinematic analysis. Superior performance is evident of a lower angle obtained at the point of analysis, thereby showing the Analogy-Live and Analogy-Video groups to have attained the greater improvements in performance. The retention period had a debilitating effect on all groups tested but showed to be more influential on those educated by explicit learning techniques. The control group showed no change in performance and remained stable throughout all stages in testing.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm that the analogy-based groups significantly improved their performance from pre-acquisition to retention testing, and from pre to post acquisition testing [Analogy-Live,  $F(1,208, 9.66)$

= 613.674,  $p < 0.001$ ;  $\eta^2 = 0.987$ ], [Analogy-Video,  $F(2,16) = 292.285$ ,  $p < 0.001$ ;  $\eta^2 = 0.973$ ]. Similarly, to the subjective scores, no significant differences were found following the retention period (post acquisition-retention).

Post-hoc analyses confirm a significant effect within the Explicit-Live [ $F(2,16) = 68.54$ ,  $p < 0.001$ ;  $\eta^2 = 0.895$ ] and Explicit-Video [ $F(2,16) = 31.48$ ,  $p < 0.001$ ;  $\eta^2 = 0.797$ ]. In both cases their performance significantly improved from both baseline to post testing, and baseline to retention. The retention period affected these groups differently, as it appeared to have no significant effect on the Explicit-Video group but the Explicit-Live displayed a significant decline in performance following the retention stage (see figure 24).

The performance of the control group remained stable throughout testing as no significant differences were found between any of the testing stages, [ $F(2,12) = 0.884$ , ns;  $\eta^2 = 0.128$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,42) = 0.561$ , ns].

Post-hoc analyses conducted following the acquisition period, showed that the analogy-based groups performed significantly better the respective explicit group [ $F(4,42) = 147.447$ ,  $p < 0.001$ ]. No significant differences were found between Analogy-Live and Analogy-Video, however the Explicit-Live group performed significantly better than Explicit-Video. All intervention based groups scored significantly higher than the control group.

Post-hoc analyses conducted following the retention stage, showed that the analogy-based groups performed significantly better the respective explicit

group [ $F(4,42) = 324.508$ ,  $p < 0.001$ ]. No significant differences were found between Explicit-Live and Explicit-Video. The Analogy-Live group performed significantly better than Analogy-Video. All intervention based groups scored significantly higher than the control group.

*Explicit Rules Formulated (RULES)*

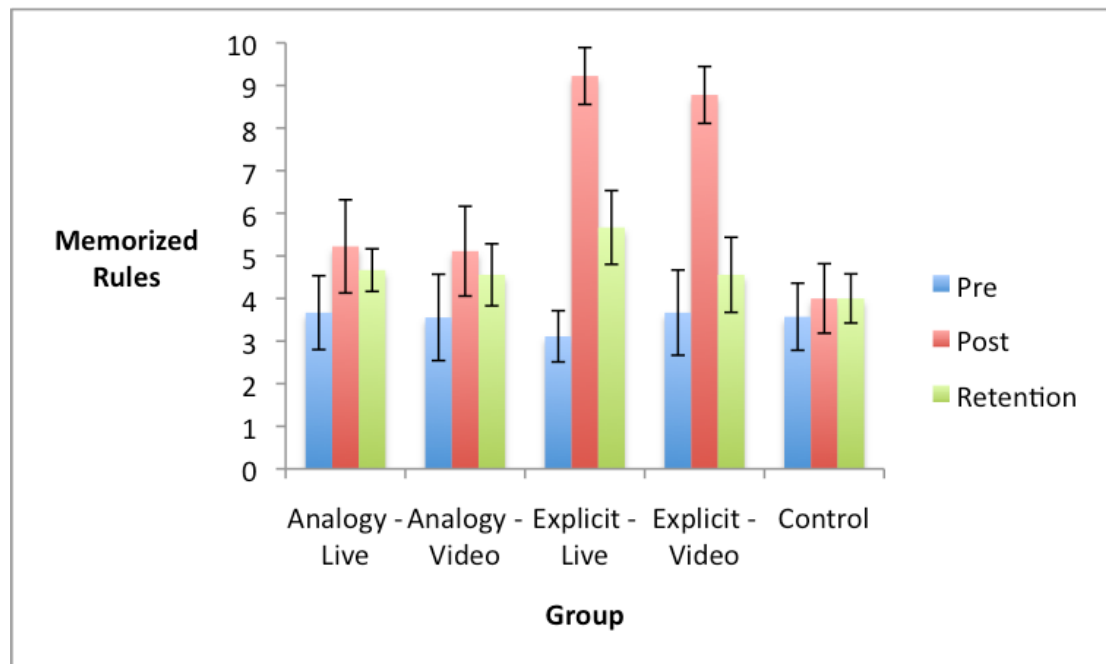


Figure 25. Mean number of explicit rules across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figure 25 shows a similar baseline understanding of the skill for all groups. Following the acquisition stage, the groups educated via analogy showed a minor increase (~30%). Comparatively, the explicitly educated groups who increased the number of rules recalled by almost three times that of pre-acquisition testing (baseline) measures. This effect was only temporary, as following the retention period, the number of rules recalled significantly reduced. This debilitating effect was also shown in the analogy groups but was only minor.



*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA showed that only a significant increase in rules recalled occurred during the acquisition stage (pre-post), for both the Analogy-Live [ $F(2,16) = 8.274, p < 0.05; \eta^2 = 0.508$ ] and Analogy-Video [ $F(2,16) = 10.982, p < 0.05; \eta^2 = 0.579$ ] groups. No significant differences were found from pre-acquisition to retention or post-acquisition to retention testing.

Both explicit-based groups showed a significant increase in rules recalled from pre-post testing, followed by a significant decrease following the retention period [Explicit-Live,  $F(2,16) = 160.632, p < 0.001; \eta^2 = 0.953$  & Explicit-Video,  $F(2,16) = 96.64, p < 0.001; \eta^2 = 0.924$ ]. Pairwise comparisons reveal that overall (pre-acquisition to retention) the Explicit-Live groups showed a significant increase, whereas the Explicit-Video showed no significant difference.

Post-hoc analysis revealed no significant differences within the control group for any testing stages [ $F(2,12) = 1.636, ns; \eta^2 = 0.214$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,42) = 0.632, ns$ ].

Following the acquisition, the Analogy-Live and Analogy-Video recalled significantly fewer rules than their video based counterpart, [ $F(4,42) = 60.721, p < 0.001$ ]. No significant differences were found between the respective live and video pairings. No significant differences were found between either of the analogy-based groups and the control, whilst both the Explicit-Live and Explicit-Video groups scored significantly higher than the control group.

No significant differences were found between the number of rules recalled by the Explicit and relative analogy-based group following retention. No significant differences were found between Analogy-Live and Analogy-Video., whilst Explicit-Live recalled significantly more rules than Explicit-Video, [ $F(4,42) = 5.672, p < 0.05$ ]. The control group showed no significant differences with any of groups with the exception of the Explicit-Live, whereby Explicit-Live recalled significantly more rules.

### 6.3.2. Reinvestment variables.

#### Movement Specific Reinvestment Scale: Total score (MSRS)

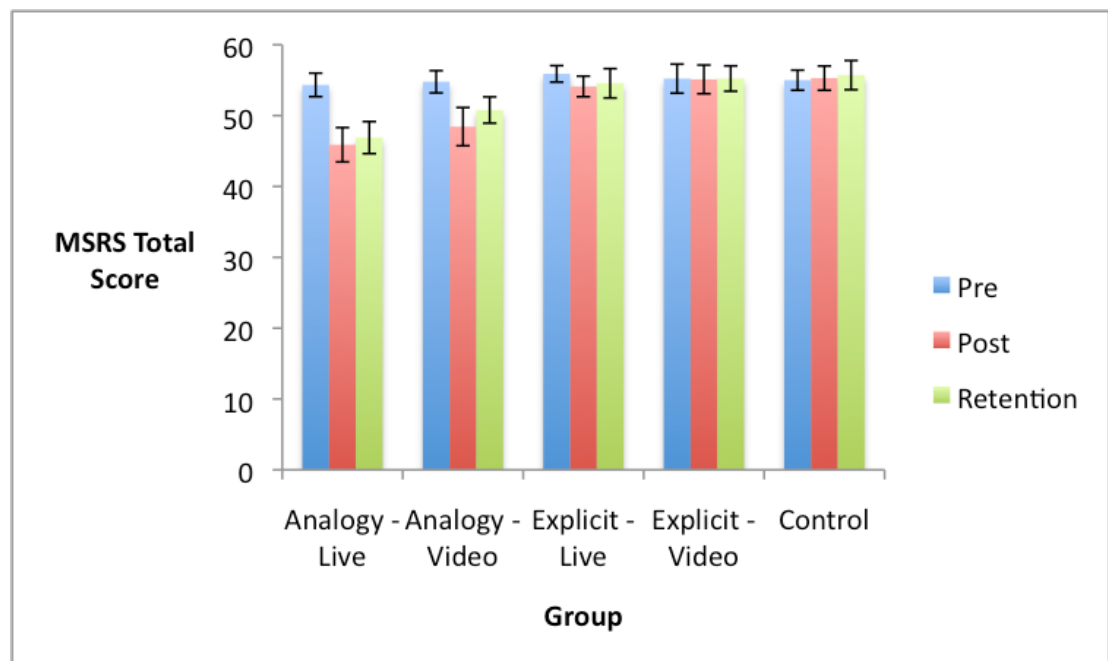


Figure 26. Mean total score of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figure 26 shows that all groups scored close to the maximum score of 60 at pretest. Following the acquisition and retention stages the groups educated via analogy showed a reduction in reinvestment score. The scores from all other groups remained stable and close to maximum values.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm that both analogy educated groups significantly decreased the reinvestment score from pre to post acquisition, and showed an overall significant decrease from pre-acquisition to retention. No significant differences were found for either group following the retention period [Analogy-Live,  $F(2,16) = 51.537$ ,  $p < 0.001$ ;  $\eta^2 = 0.886$ , & Analogy-Video,  $F(2,16) = 23.828$ ,  $p < 0.001$ ;  $\eta^2 = 0.749$ ].

All other groups, including the control [ $F(2,12) = 0.344$ , ns;  $\eta^2 = 0.054$ ] and both explicit-based learning groups, [Explicit-Live,  $F(2,16) = 3.308$ , ns;  $\eta^2 = 0.293$  & Explicit-Video,  $F(2,16) = 0.016$ , ns;  $\eta^2 = 0.002$ ] showed no significant differences throughout testing stages.

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,642) = 1.154$ , ns].

Post-hoc analysis showed a significant effect within the post-acquisition stage data, [ $F(4,42) = 35.612$ ,  $pp < 0.001$ ]. Analogy-based groups scored significantly lower than their explicit counterpart. No significant differences were identified between live and video comparisons. The control group showed no significant differences between explicit-based groups, whereas both the Analogy-Live and Analogy-Video groups scored significantly lower than the control group.

Following the retention period, Analogy-Live and Analogy-Video scored significantly lower than the relative explicit-based group [ $F(4,42) = 30.116$ ,  $p < 0.001$ ]. The Analogy-Live group scored significantly lower than Analogy-Video, whilst no significant differences were found between Explicit-Live and

Explicit-Video. Both analogy-based groups scored significantly lower than the control group, whilst neither the Explicit-Live nor Explicit-Video showed a significant difference in reinvestment score.

Conscious Motor Processing: sub-scale score (CMP)

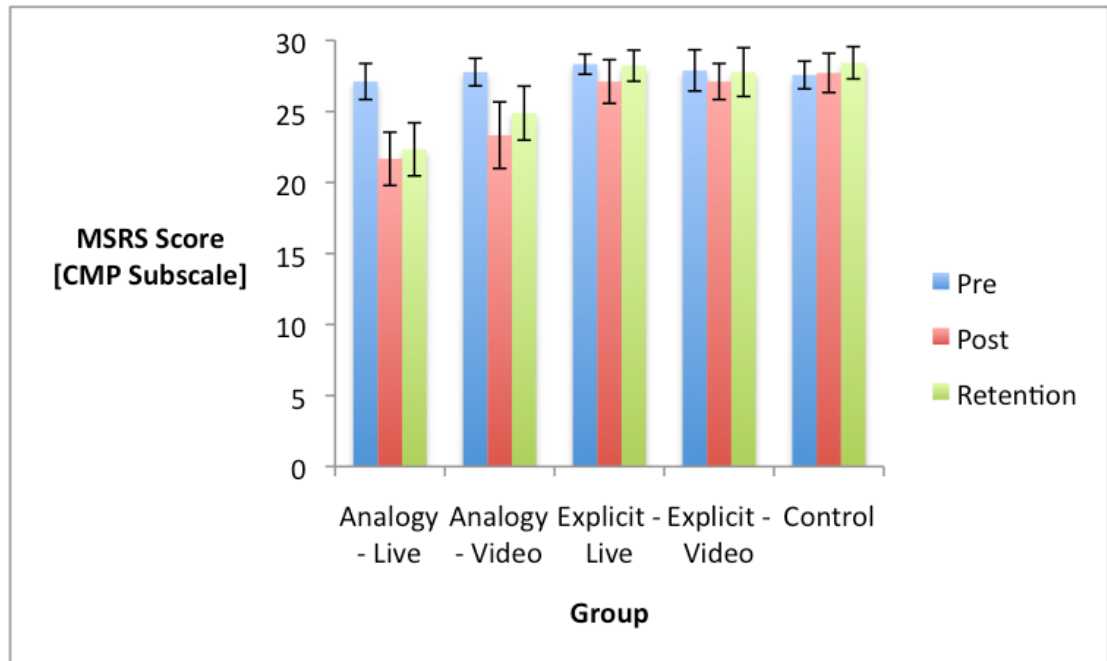


Figure 27. Mean score of the Conscious Motor Processing sub-scale (CMP) of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Figures 27 & 28 show similar trends from the four intervention groups. Following acquisition, reinvestment scores on this sub scale showed a reduction followed by an increase after the retention period. The size of this effect differed between educational techniques. Those undergoing education via analogy, showed a significant reduction followed by a minimal reform. Explicit-based groups showed minimal reduction that reverted back to pre-acquisition testing (baseline) scores following the retention period.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm that both analogy educated groups significantly decreased the reinvestment score from pre to post acquisition, and showed an overall significant decrease from pre-acquisition testing (baseline) to retention. No significant differences were found for either group following the retention period [Analogy-Live,  $F(2,16) = 25.78$ ,  $p < 0.001$ ;  $\eta^2 = 0.763$ , & Analogy-Video,  $F(2,16) = 12.825$ ,  $p < 0.001$ ;  $\eta^2 = 0.616$ ].

All other groups, including the control [ $F(2,12) = 1.292$ , ns;  $\eta^2 = 0.177$ ] and both explicit-based learning groups, [Explicit-Live,  $F(2,16) = 3.442$ , ns;  $\eta^2 = 0.301$  & Explicit-Video,  $F(2,16) = 0.95$ , ns;  $\eta^2 = 0.106$ ] showed no significant differences throughout testing stages.

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,42) = 1.441$ , ns].

Post-hoc analysis showed a significant effect within the post-acquisition stage data, [ $F(4,42) = 35.612$ ,  $pp < 0.001$ ]. Analogy-based groups scored significantly lower than their explicit counterpart. No significant differences were identified between live and video comparisons. The control group showed no significant differences between explicit-based groups, whereas both the Analogy-Live and Analogy-Video groups scored significantly lower than the control group.

Following the retention period, Analogy-Live and Analogy-Video scored significantly lower than the relative explicit-based group [ $F(4,42) = 30.116$ ,  $p < 0.001$ ]. The Analogy-Live group scored significantly lower than Analogy-Video, whilst no significant differences were found between Explicit-Live and

Explicit-Video. Both analogy-based groups scored significantly lower than the control group, whilst neither the Explicit-Live nor Explicit-Video showed a significant difference in reinvestment score.

*Movement Self-Consciousness: sub-scale score (MS-C)*

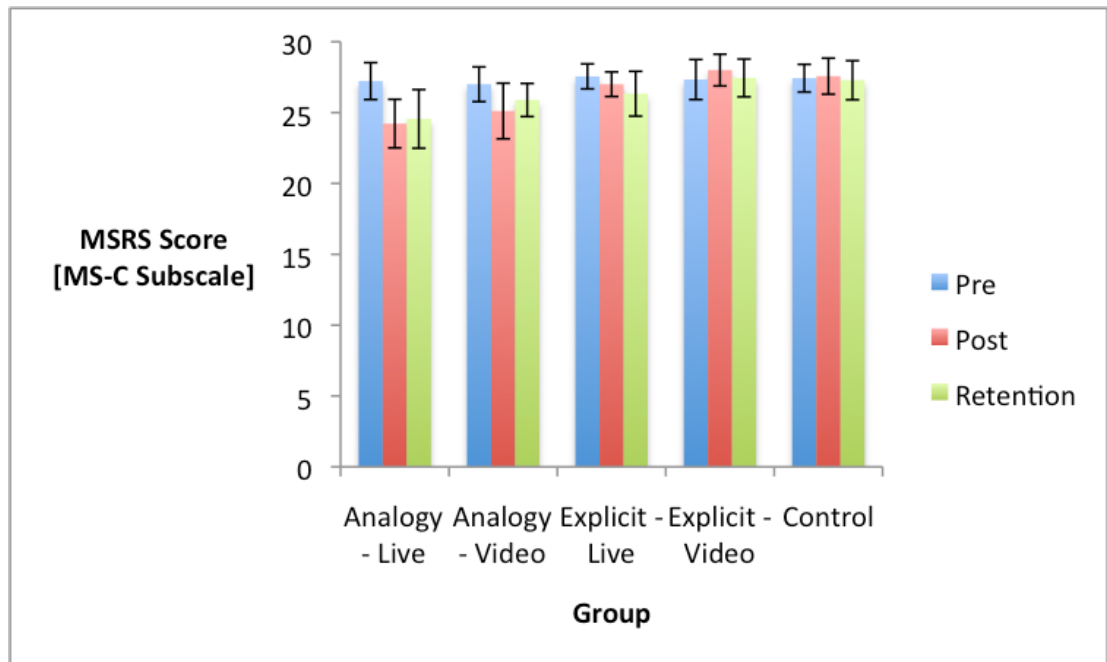


Figure 28. Mean score of the Movement Self-Consciousness sub-scale (MS-C) of the Movement Specific Reinvestment Scale (MSRS) (Masters et al, 2005) across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

*'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm that the Analogy-Live group, significantly decreased the reinvestment score from pre to post acquisition, and showed an overall significant decrease from pre-acquisition to retention [ $F(2,16) = 25.78$ ,  $p < 0.001$ ;  $\eta^2 = 0.763$ ]. No significant differences were found following the retention period.

The control [ $F(2,12) = 0.222$ , ns;  $\eta^2 = 0.036$ ], and all other intervention groups; Analogy-Video, [ $F(2,16) = 4.263$ , ns;  $\eta^2 = 0.348$ ], Explicit-Live, [ $F(2,16) = 2.028$ , ns;  $\eta^2 = 0.202$ ], Explicit-Video, [ $F(2,16) = 0.734$ , ns;  $\eta^2 = 0.084$ ] showed no significant differences throughout testing stages.

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage, [ $F(4,42) = 1.154$ , ns].

Post testing data showed that the analogy-based groups scored significantly lower compared to the relative explicit group, [ $F(4,42) = 11.055$ ,  $p < 0.001$ ]. No significant differences were identified between live and video comparisons. Both analogy-based groups scored significantly lower than the control group, whilst neither the Explicit-Live nor Explicit-Video showed a significant difference in reinvestment score.

Following the retention period, post-hoc analysis confirmed a single significant differences between the Analogy-Live and Explicit Video [ $F(4,42) = 4.964$ ,  $p < 0.05$ ]. No significant differences were found between relative analogy and explicit groups, or live and video comparisons. The control group showed no significant differences between any of the learning intervention groups.

### 6.3.3. Sensation Seeking variables

#### Sensation Seeking Scale V: total score (SSSV)

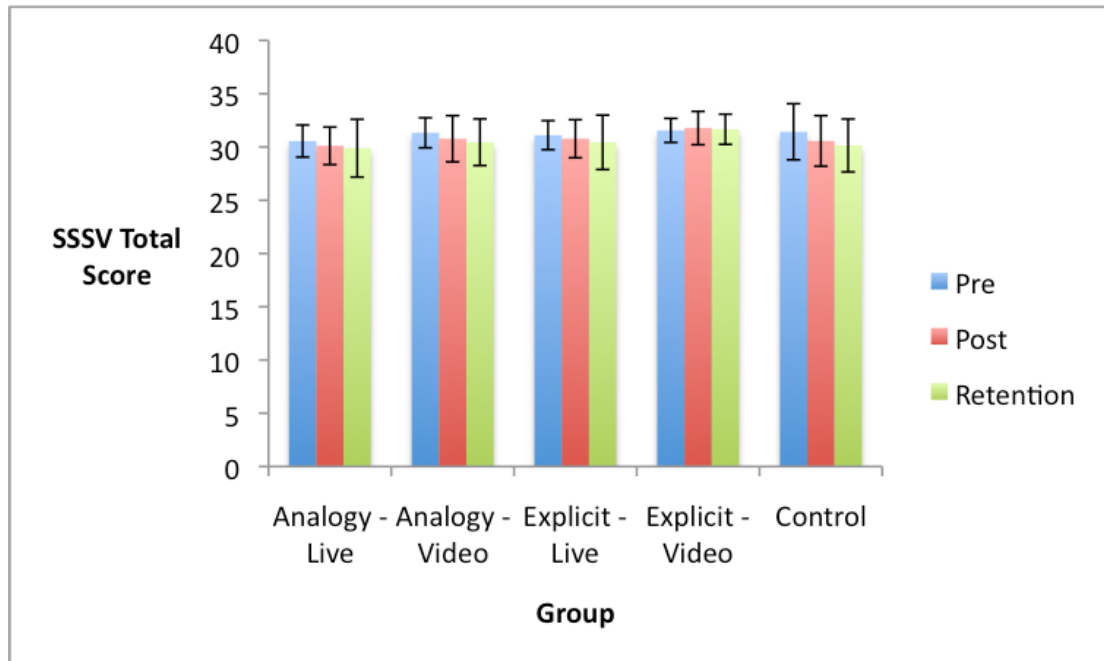


Figure 29. Mean total score for the Sensation Seeking Scale V (SSSV) (Zuckerman, 1978) across all three testing stages in experimental study 4 for all groups: Analogy-Live (ANL), Analogy-Video (ANV), Explicit-Live (EXL), Explicit-Video (EXV), Control.

Shown in Figure 29, all groups scored equally high on sensation seeking tendencies. These remained stable throughout testing and this trend was shown for the subsequent sub-scales.

#### *'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live, [ $F(2,16) = 0.3$ , ns;  $n^2 = 0.036$ ], Analogy-Video, [ $F(2,16) = 0.401$ , ns;  $n^2 = 0.048$ ], Explicit-Live, [ $F(2,16) = 0.209$ , ns;  $n^2 = 0.025$ ], Explicit-Video, [ $F(2,16) = 0.066$ , ns;  $n^2 = 0.008$ ] and control, [ $F(2,12) = 0.454$ , ns;  $n^2 = 0.07$ ].



*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage [ $F(4,42) = 0.514$ , ns], post acquisition [ $F(4,42) = 0.89$ , ns] or following the retention period [ $F(4,42) = 0.776$ , ns].

*Thrill & Adventure Seeking: sub-scale score (TAS)**'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live, [ $F(2,16) = 0.229$ , ns;  $n^2 = 0.028$ ], Analogy-Video, [ $F(2,16) = 0.039$ , ns;  $n^2 = 0.005$ ], Explicit-Live, [ $F(2,16) = 0.125$ , ns;  $n^2 = 0.015$ ], Explicit-Video, [ $F(2,16) = 0.25$ , ns;  $n^2 = 0.03$ ] and control, [ $F(2,12) = 0.041$ , ns;  $n^2 = 0.007$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage [ $F(4,42) = 0.136$ , ns], post acquisition [ $F(4,42) = 0.194$ , ns] or following the retention period [ $F(4,42) = 0.05$ , ns].

*Experience Seeking: sub-scale score (ES)**'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live, [ $F(2,16) = 0.016$ , ns;  $n^2 = 0.002$ ], Analogy-Video, [ $F(2,16) = 1.947$ , ns;  $n^2 = 0.196$ ], Explicit-Live, [ $F(2,16) = 0.233$ , ns;  $n^2 = 0.028$ ], Explicit-Video, [ $F(2,16) = 0.308$ , ns;  $n^2 = 0.037$ ] and control, [ $F(2,12) = 0.24$ , ns;  $n^2 = 0.038$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage [ $F(4,42) = 0.159$ , ns], post acquisition [ $F(4,42) = 0.236$ , ns] or following the retention period [ $F(4,42) = 0.2$ , ns].

*Boredom Susceptibility: sub-scale score (BS)**'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live, [ $F(2,16) = 3.127$ , ns;  $n^2 = 0.281$ ], Analogy-Video, [ $F(2,16) = 0.159$ , ns;  $n^2 = 0.019$ ], Explicit-Live, [ $F(2,16) = 0.173$ , ns;  $n^2 = 0.021$ ], Explicit-Video, [ $F(2,16) = 1.134$ , ns;  $n^2 = 0.124$ ] and control, [ $F(2,12) = 2.4$ , ns;  $n^2 = 0.286$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage [ $F(4,42) = 0.103$ , ns], post acquisition [ $F(4,42) = 0.355$ , ns] or following the retention period [ $F(4,42) = 3.153$ , ns].

*Disinhibition: sub-scale score (DIS)**'Within Perspective' (pre vs post vs retention)*

Post-hoc one-way ANOVA confirm no significant differences between any of the testing stages, within any of the groups; Analogy-Live, [ $F(2,16) = 0.025$ , ns;  $n^2 = 0.003$ ], Analogy-Video, [ $F(2,16) = 0.25$ , ns;  $n^2 = 0.03$ ], Explicit-Live, [ $F(2,16) = 0.000$ , ns;  $n^2 = 0.000$ ], Explicit-Video, [ $F(2,16) = 0.772$ , ns;  $n^2 = 0.088$ ] and control, [ $F(2,12) = 0.28$ , ns;  $n^2 = 0.005$ ].

*'Between Perspective' (all groups)*

Post-hoc one-way ANOVA confirmed no significant differences between any of groups tested at the pretest stage [ $F(4,42) = 0.428$ , ns], post-acquisition [ $F(4,42) = 0.355$ , ns] or following the retention period [ $F(4,42) = 0.282$ , ns].

**6.4. Discussion**

Initially it is important to confirm the personality trait most commonly related to individuals associated with high-risk behaviour. The results of the sensation seeking variables demonstrate that all groups scored highly throughout all testing phases on this personality trait. This lack of change is common as the trait, as noted, is considered to be stable and the existence supports the notion of all participants being reminiscent of the personality which engages in high-risk sports (Zuckerman, 2007).

The aim of this study was to examine the effectiveness of different learning strategies for skill acquisition in high-risk sports. The control group provided inference of causality by showing no significant differences between itself and the intervention groups at pre-acquisition testing (baseline). The control group showed no significant change in any variables throughout any stage of testing. This supports any changes in other groups can be attributed to the interventions applied and these differences were protected against confounding variables.

When comparing the analogy and explicit groups directly, the analogy intervention resulted in several key behaviours. Firstly, the analogy-based

learning interventions produced significantly superior performance both immediately after and following the two week post intervention. Secondly, the two-week retention period was shown to be significantly detrimental to those educated via explicit means only. The performance derived by the analogy intervention was found to be robust and showed no significant change in score following the retention period.

Regarding the ongoing debate throughout this research of live compared to video instruction, significant differences were identified. The previous studies in earlier chapters failed to identify any potential effect concerning the delivery method of the information needed for acquisition. This chapter focussed on professional athletes and has shown that explicit instruction delivered significantly better performance through live methods over video when applied short term. This only occurred immediately following the intervention. After undergoing the retention period both methods were significantly hindered to the point where neither group performed better. A contrasting effect was shown in the analogy groups. Mode of delivery was shown not to be significant, although both groups showed superior performance compared to their explicit counterparts.

These behaviours can be justified using the theoretical arguments proposed earlier in chapter two. Attentional bias created by anxiety/fear from the risk involved within such sports as skateboarding has been shown possible in the previous chapters. Likewise, the behaviour exhibited in the current study could be attributed to the same incurrence of reinvestment.

Given the professional status of the sample in the current study, the notion of fear, anxiety or other negative emotions towards risk are arguably

less likely to apply. The attributes of professional athletes are dedication, willpower, and an overall lifestyle commitment to their chosen sport (Mango, 2012). In order to achieve this status in high-risk sports, it would appear illogical if the defining attributes of the sport (e.g. risk/fear) could only be perceived negatively. Brymer & Schweitzer (2012) have shown that high-risk sportsmen do acknowledge the fear involved in participation. The research found fear to be seen as unwelcome but justified as a 'necessary evil' that is the important and defining aspect of these sports. Documentaries within skateboarding have revealed that the relationship with fear is seen as positive, and often the attractive feature of overcoming the obstacle (Rodriguez, 2017; Cole, 2012; Way, 2012).

This viewpoint could be argued as desirable and supported by the elaboration intrusion theory of craving (Kavanagh et al, 2005). The theory is based on the assumption that desires, be it cravings (food, drugs etc.) or emotional dependence (empathy of a loved one or thrill of excitement) can result in appetitive targets automatically triggering intrusive thoughts. Elaboration intrusion theory of craving is assumed to have two effects, one automatic and associated with pleasure, whilst the second is cognitively mediated causing elaboration on the cue. These elaborations are believed to interfere with the operation of working memory by displacing more constructive thoughts. This is similar to the disruptive interference caused by worry in previous theories. The elaboration stimulates the characteristics of the target, leading to temporary emotional rewards. The defining characteristic of these sports is overcoming the risk involved by successfully participating. In accordance with the elaboration intrusion theory, this aspect would be highlighted and therefore prominent in creating an attentional bias towards a 'success by survival'

approach. By highlighting the risk and necessity to succeed, it will turn the focus of attention on the target skill, creating an internal focus of attention towards their actions (otherwise referred to as reinvestment).

Reinvestment may be the conceptual root of the problem, as mentioned previously in earlier chapters. Reinvestment theory attributes this overwhelming effect on working memory and subsequent performance to a conscious inward focus of attention. Baseline measures of movement specific reinvestment confirm all five experimental groups to exhibit an exceptionally high propensity to reinvest (scores of fifty, of a potential sixty). Upon applying the interventions, reinvestment scores from those educated via analogy reduced significantly (approx. 20%). The opposite effect was evident by the explicit intervention. Whist performance significantly declined, the reinvestment scores either significantly increased or remained at their heightened baseline measure. Further analysis of the measured sub scales within reinvestment can identify that this effect was shown in both Conscious Motor Processing (CMP) and Movement Self-Consciousness (MS-C), which are theoretically related to both the mechanics and the aesthetics of the movement. This is expected within professional high-risk sportsmen as not only is it important to perform the skills successfully, but scoring is also reflected on the artistic personalisation in how the skill is performed aesthetically (Rodriguez, 2017; Cole, 2012).

No significant differences were identified within the explicit groups regarding reinvestment, as they remained consistently heightened. This may be a reflection on the measurement scale used, as ceiling effects may be possible as close to maximum scores were attained at baseline.

The notion of overwhelming working memory capacity can be supported by the inferior performance measures, with the collective results from the consciously recalled rules and movement reinvestment scores. All of the learning interventions resulted in a significant increase in conscious awareness of coaching points compared to baseline measures initially but differed following the retention period. The analogy groups appear to have retained their information as no differences were found following the retention period, whilst those educated explicitly suffered a significant decrease in recollection. When compared with one another analogy resulted in significantly less recalled declarative knowledge following the intervention compared to explicit. Following the retention period, the explicitly educated groups suffered a further decrease in recollection. This resulted in equality to the analogy groups as minimal declarative knowledge was evident from all groups involved. Those educated via analogy, still demonstrated significantly superior performance in comparison, despite having a limited pool of declarative knowledge available. This inverse relationship between performance and declarative understanding via analogy intervention has been shown in a myriad of research (Tse et al, 2017a;2017b; Tzetzis & Lola, 2015; Lam et al, 2009a; 2009b; Masters et al, 2008a; Poolton et al, 2007b; Liao & Masters, 2001).

Analogy learning is not designed to inhibit conscious awareness but simply limit the amount of declarative knowledge available (Masters et al, 2008). Given that these participants are of a higher learning calibre, it is understandable that a degree of conscious awareness is possible when questioned. As mentioned earlier, the concept is to limit awareness to remain within a tolerable degree for working memory. Although all four interventions showed an improvement in performance, the analogy interventions recalled

significantly less rules than other groups (including control), whilst showing superior performance in comparison. This indicates a potential argument for the degree of conscious awareness created by analogy, being within the functional parameters of working memory, whilst the explicit instruction exceeded such.

Research conducted on expert or professional athletes in swimming (Komar et al, 2016), soccer (Adams et al, 2014), field-hockey (Winter & Collins, 2013), darts (Schorer et al, 2012), golf (Beilock et al, 2002), and baseball (Gray, 2004; Allard & Burnett, 1985) has shown that by directing attention externally from the movements performed allows the automated procedural knowledge to occur more effectively. This is in accordance with the constrained action hypothesis, whereby an internal focus of attention encourages conscious control of movements, inherently inhibiting automatic control mechanisms (McNevin, Shea & Wulf, 2003). This inhibiting factor can be amplified in more expert, professional athletes due to the heightened automatic processes that have been developed and subsequently more dependent on performance. By limiting the degree of conscious awareness of the skill via analogy, this minimises the inhibitory effect on the movement production. It should also be noted that this effect was shown in sports categorised as low-risk (Zukerman, 2007) whilst also lacking an environmental stressor. The effect of stress on performance irrespective of learning stage has been outlined in chapter 2. Combining such a further confounding factor of possible preferred automated dependency within professionals, provides further support for the results on this study, and the strength of performance created via analogy instruction. The study of this chapter also strengthens the concept of high-risk sporting athletes demonstrating a higher propensity to reinvest within their actions



compared to previous research on professionals in low-risk sports. As mentioned in the introduction of this chapter, research conducted on highly experienced professional athletes yielded scores within the mid-forties pertaining to Movement Specific Reinvestment (Geukes et al, 2017; Iwatsuki & Wright, 2016) compared to the current findings whereby maximal scores were obtained. This difference is exhibited as a 30% increase on average to that of previous research conducted on a low-risk sporting sample of similar expertise. This is support for the overall study aim on the suggestion of original contribution of knowledge, as sports enduring high-risk physical threat can exhibit a unique approach to cognition and therefore learning.

The results from this study on professionals may have shown minor unique differences but the overall trends have repeated themselves across all stages of learning. Successful skill acquisition can occur in high-risk sports using either approach; be it explicit or implicit in nature. Superior performance was acquired via analogy learning and was shown to be more robust to temporal deterioration, allowing for learning to successfully endure well beyond the acquisition phase. The dividing feature between live and video instruction failed to provide any benefit, ensuring both modalities to be effective holistically. As noted, the current study lends support to the overall aim of the thesis by illustrating the benefits of implicit-based learning interventions at the highest stage where performance is saturated with the risk factor.

The final chapter is designed to integrate the findings of all studies exploring the theoretical explanations identified in chapter two. The underlying mechanisms of working memory will be discussed and the influential effect that an attentional bias can interfere with skill acquisition in high-risk sports.

# Chapter 7

## General Discussion

The current thesis had two main overarching aims as discussed at the end of chapter 1. The first was to examine the effect of reinvestment and various practice-based learning strategies (analogy, guided discovery, explicit) in high-risk sports regarding conscious control of action (aim 3). The use of implicit/explicit measures had yet to be tested within a physically high-risk sporting environment and provide substantial support for both the high-risk sports industry, and ongoing scientific study of conscious control amidst anxiety and arousal (aim 3).

Furthermore, this thesis aimed to provide initial insight into the application of such learning strategies using a complex whole-body movement (aim 4). Research to date, has focussed on simple movement patterns using fine motor control and minimal coordination (e.g. darts, van Ginneken et al, 2017). By examining effectiveness using a complex, highly coordinated, whole body movement, it supported the field of research with greater ecological validity and practicability (aim 4).

In addition, this thesis aimed to provide further insight into the ongoing debate between live versus video instructional modelling (aim 5). To date, minimal research had examined the two modes of instruction in direct comparison within the same study. Experimental reliability can be sustained by directly comparing both forms of modelling using the same task and sample in a sporting context.

Secondly, this thesis aimed to investigate the potential differences and subsequent effects of these learning strategies at various stages of the learning spectrum from novice to professional (aim 6). The majority of the research conducted to date has focussed on the initial novice stage, whereby tasks and subsequent risk can be lower. Physical risk has yet to be examined in a sporting context regarding conscious control and manipulation of reinvestment (aim 7). Risk (physical harm) increases both between high and low-risk classified sports (e.g. snowboarding and golf) along with complexity and performance (Zuckerman, 2014). This increase in risk can inherently influence reinvestment at the various stages of learning and performance. Examining any variance in effectiveness of learning strategy at each stage (novice, experienced, etc.) would highlight any need to alter the approach to learning, regarding conscious control.

To satisfy these aims, the initial step was to identify if the unique characteristic associated with risky behaviour known as Sensation Seeking (Zuckerman, 2007) was evident with the high-risk sporting population (aim 2). Sensation seeking is a personality trait deemed to be responsible for the pursuit of novel stimulation, and subsequently linked to abnormalities within the body's optimal level of arousal (Zuckerman, 2014), of which attention and potential reinvestment are influenced.

The initial study (chapter 3) identified that high-risk sports demonstrated significantly stronger traits of sensation seeking compared to low-risk matched pairs. This pattern was evident in all aspects of performance through amateur/professional status, and all progressions of learning background: novice, intermediate and experienced.

The current results concur with existing research in high-risk sports; defined by Zuckerman (2007) as participation in sports whereby the risk of severe injury or possible death is apparent. High-risk sporting populations (rafting, parachuting, surfing, snowboarding, skiing) when compared to low-risk controls have scored significantly higher on Thrill & Adventure Seeking and Experience Seeking sub-scales and total sensation seeking (Rhea & Martin, 2010; Cazenave et al, 2010; Diehm & Armatas, 2004; Goma-i-Freixanet, 2001). Scores within the sub-scales Boredom Susceptibility (BS) and Disinhibition (Dis) are inconsistent throughout research in high-risk sports (Goma-i-Freixanet, et al, 2012). Lower scores in Boredom Susceptibility have been attributed to development of patience, given the nature and preparation required to participate (Diehm & Armatas, 2004). This was not apparent in chapter 3 as BS scores were shown to be significantly higher compared to low-risk matched pairs. This may be attributed due to the single sporting populous of surfing chosen by Diehm & Armatas (2004). Surfing is primarily environmentally paced, by that participants are at the mercy of tides function. Surfers accounted for a small collection of the overall sample involved in chapter 3, and included other self-paced high-risk sports (snowboarding, skateboarding and freestyle BMX) that offer more promptly accessible participation within the environment.

Considering the overall findings of chapter 3 relating to sensation seeking, it is feasible that performers in high-risk sporting culture may have abnormalities within optimal level of arousal, and therefore attention and focus. Acquisition of movement patterns to perform successfully are dependent on attentional constraints. Given that the cerebral cortex is impacted by sensation

seeking (Zuckerman, 2007), and shares functional aspects of the brain responsible for movement coordination (Gelb, 2016), this could inherently impact skill acquisition within high-risk sports.

Based on the findings regarding sensation seeking, it was important to explore if differences in the propensity to reinvest existed between sports of high and low-risk nature. The term 'reinvestment' is defined as the manipulation of conscious, explicit, rule-based knowledge from working memory, to control the mechanics of movement during skill execution (Masters, 1992). Reinvestment theory, originally proposed by Masters (1992), suggests that reinvesting within movement can disrupt motor production through conscious control using declarative (conscious) knowledge. Subjects who are exposed to stress can instinctively reinvest depending on the emotional strength of this exposure. Comparing the reinvestment propensity of high and low-risk sports directly with one another would identify if the stress derived from risk of physical harm influenced reinvestment. The initial study of this thesis (chapter 3) provided this insight, whilst extending the scope to progression within the different sporting cultures.

The results from the initial study confirmed individuals engaged in high-risk sports, score significantly higher on the Movement Specific Reinvestment Scale (MSRS). When dividing the data based on 'experience' the results again showed that regardless of learning stage, those participating in high-risk sports scored significantly higher than lower risk sporting counterparts. Research to date has yet to identify this within modern day high-risk sports (e.g. skateboarding) highlighting the originality of this research.

The nature of the reinvestment remains the same regardless of risk involved within the sport. At a novice level, the majority of the reinvestment is generated from focus on the mechanics of the movement, as shown by results of the Conscious Motor Processing sub-scale. The data indicates whilst learning progresses through to the latter stages, the focus shifts towards the artistic, more visual demands of the task as shown by the Movement Self-Consciousness sub-scale. This finding presents support for the proposal of Movement Specific Reinvestment (Masters et al, 2005).

Significant differences are shown, by trends in reinvestment within each sporting sample as progression from novice to expert occurs. High-risk sports score significantly higher throughout each stage of progression, whilst lower risk sports reinvest significantly less through each stage from novice to expert. These results agree (in part) with existing literature regarding low-risk activities (e.g. tennis, golf etc). In accordance with the Multi Stage Learning Theory (Fitts & Posner, 1967), as learning progresses from a cognitive through to an autonomous stage, the skill requires less conscious control. Masters (1992), states that because less control is required to moderate the skill consciously, the demand to reinvest becomes reduced.

The high-risk sports groups however, contradict previous literature and the tenets of both the Multi Stage Learning Theory (Fitts & Posner, 1967) and the Reinvestment Theory (Masters, 1992). Reinvestment significantly increased at each proposed stage of learning within sport groups of high-risk. This can potentially be attributed to a self-preservation mechanism governed by a threat detection system or similar. High-risk sport participants engage in dangerous activities, whereby failure to execute the skill can result in severe physical harm. This form of stress can then result in greater reinvestment as

an attempt to minimise this risk by ensuring the skill is performed successfully, as it is the safest option available.

Research conducted on high-risk sports has shown the relationship between high-risk sports participation and fear is both complex and strong (Way, 2012; Brymer & Schweitzer, 2012). Brymer & Schweitzer (2012) dispelled the common myth of high-risk sportsmen being 'fearless'. Results not only showed that fear is acknowledged, but also revered, respected and renowned as an integral aspect of the attraction to such sports. One participant identified that the fear gives them a feeling of slowing down time, allowing them to focus on a meta-perspective whereby the objective goal is of primary concern. Given that fear can be held in such high regard, the possible attentional bias created can support the notion that fear can draw attention to mechanics of the movement. This would explain the increased propensity to reinvest seen in the initial study by the high-risk sports sample.

Many models were outlined in chapter 2 detailing the various interpretations of what can govern individuals' attentional bias towards threatening stimuli. The most basic of the models is that of the cognitive model by Beck & Clark (1997). It suggests that anxiety or fear can activate a 'primal mode' whereby the initial registration of the threat stimuli leads to a reflective, elaborate form of thinking. Ohmans (1996) feature detection model shares similar aspects. Upon detection of threatening stimuli, information enters a significance evaluation system. During this point information, surrounding conscious perception, enables a slow process of conscious appraisal interacting with past memories. According to the model, this can enable a feedback loop whereby appraisal of the situation and memories can increase

arousal, thus sensitising the significance evaluation system further. This interaction with past memories may contribute to the reinvestment propensity increasing with experience as it allows for a deeper evolution of more memories. Additionally, the risk involved in participation at higher levels of experience invokes a greater level of risk as complexity is heightened and target goal/skill is more dangerous (Cole, 2012).

Mogg & Bradley's (1998) cognitive motivational model acknowledges the involvement of goal-oriented objectives. Attention to threat is firstly appraised by a valence evaluation system through consideration of contextual information and prior learning. Based on these reflections, information is then fed into goal engagement system. High threats cause current behaviour to be abandoned and the current cause to be attended to. Low or mild threats generally are cast aside, and current behaviour can continue uninhibited. These systems are echoed within the Bar-Haim et al (2007) model, using a pre-attentive threat evaluation system, guided threat evaluation system, and goal engagement system.

Both of these models consider the involvement of goal orientated behaviour, more specifically this can only become deprioritised by a highly threatening stimuli, of which heightened arousal can be expected to interfere with performance outcome if raised beyond optimal levels (Cisler & Koster, 2010). These models assume that highly threatening stimuli and goal orientated behaviour are mutually exclusive as threat is viewed more of a distraction in design. The results from the current thesis identify a unique increased propensity to reinvest. It is plausible that this unique sporting culture can provide a different view on threat. The concept of high-risk sportsmen viewing threat as welcoming and even insightful has shown to be characteristic of this



culture (Rodriguez, 2017; Zuckerman, 2014; Brymer & Schweitzer, 2012, Way, 2012).

The working concept of this thesis is that high-risk sport athletes will show a higher propensity to reinvest within their movements as a result of directing attention towards the movement mechanics in an attempt to minimise the severe physical risk aligned with failure. If this notion were to be transferred to the models mentioned throughout this chapter, attention would be directed and fixated on threat and therefore reinvestment of one's movements. This would also be amplified as the goal engagement systems (considered by Mogg & Bradley, 1998 and Bar Hair et al, 2007) would be aligned with the evaluated highly threatening stimuli.

The primary aim of this thesis was to examine the effect of reinvestment and various practice-based learning strategies (analogy, guided discovery, explicit) in high-risk sports regarding conscious control of action. The evidence provided in relation to attentional bias towards threat outlined above and the studies of skill acquisition under stress (chapter 2), highlight the potential of exploring the current void in skill acquisition literature in high-risk sports. Results from the three experimental learning studies confirmed that this unique sporting culture can be facilitated by using more implicit-based skill acquisition techniques. As within study 1 (chapter 3), the results of sensation seeking variables examined within studies 2-4 confirmed that the samples chosen for skill acquisition studies exhibited high, stable levels of sensation seeking. The stability is common and is indicative of the 'extreme' individual typically engaged in high-risk behaviour (Zuckerman, 2007).

Study 1 (chapter 3) produced an interesting finding by the degree reinvestment increased from novice to experienced and subsequently professional. The subsequent studies (chapters 4, 5 & 6) examined the impact of different learning interventions within each of the different samples. All experimental studies followed a similar design consisting of 5 groups; 4 intervention based with a single control group. Implicit and Explicit-based interventions were compared to one another involving a video and live based instructional counterpart. The means of inducing implicit learning altered throughout the experimental studies in accordance with the experience level, however the overall objective was to complete an implicit-based learning technique alongside a more explicit-based instruction. The dependent variables involved throughout all the experimental studies remained the same, yielding consistent findings across studies 2-4 (chapters 4, 5 & 6).

#### Performance variables within experimental studies

The control group supported causal inference by showing no significant differences in any variable between itself and the intervention groups at pre-acquisition testing (baseline). No significant change was shown in any variables throughout any stage of testing. This suggests any changes in other groups can be attributed to the intervention applied and these differences were protected against confounding variables.

When comparing the implicit and explicit groups directly, the implicit-based intervention resulted in several key behaviours. Firstly, the implicit-based learning interventions produced significantly superior performance in both objective and subjective performance measures. This was shown post intervention and following the retention period. Secondly, the retention period

was shown to be significantly detrimental to those educated via explicit means only. The performance derived by the implicit interventions was found to be robust and showed no significant change in score following the retention period.

Regarding the ongoing debate throughout this thesis of live compared to video instruction, significant differences were identified. The initial two experimental studies failed to identify any potential effect concerning the delivery method, showing no significant performance differences between live and video counterparts. Study 4 focussing on professional athletes however, revealed that explicit instruction delivered significantly better performance through live over video methodology when applied short term. This only occurred immediately following the intervention, and failed to exist after the retention period. After the retention period both methods were significantly hindered whereby neither group performed superior over another. This remains consistent with the findings throughout the thesis whereby no lasting benefit is witnessed using live or video instruction.

Evidence within high-risk sports has shown the use of both video (Ellmer & Rynne, 2019; Enright & Gard, 2016; Boyce & Bischak, 2010; Booth & Thorpe, 2007) and live modelling from a peer (Enright & Gard, 2016; Boyce & Bischak, 2010) as effective means of feedback delivery to improve performance. This may account for the effective use of both modes of delivery within the current study, as both modes are regularly used within the sporting culture (Ellmer et al, 2019).

These behaviours can be justified using the theoretical arguments proposed earlier in chapter two. Attentional bias created by anxiety/fear from the risk involved within such sports as skateboarding has been shown possible in the previous chapters.

*Reinvestment variables within experimental studies*

Reinvestment theory (Masters, 1992) attributes an overwhelming effect on working memory and subsequent performance to a conscious inward focus of attention. During all three experimental studies, reinvestment was measured using the Movement Specific Reinvestment Scale (Masters et al, 2005) consisting of two sub scales. These are known as Conscious Motor Processing and Movement Self-Consciousness, responsible for movement mechanics and movement aesthetics respectively.

Throughout all three skill acquisition studies (chapters 4, 5 & 6), although minor differences in behaviour regarding reinvestment were reported, several overarching trends became evident. Firstly, in conjunction with the initial study, baseline reinvestment propensity was shown to amplify as the experience of the target sample increased. Secondly, implicit-based learning interventions were shown to have substantial beneficial effects (when observed in respect to the performance measures). Novice participants showed a reduction in reinvestment following implicit-based learning strategies by approximately 7% in comparison to the control group. More experienced and professional participants experienced a beneficial effect of 27% and 14% respectively. Less experienced individuals favoured higher scores in Conscious Motor Processing. As experience increased, these high scores remained evident, but scores in Movement Self-Consciousness also amplified. This indicates the

importance of artistic integrity regarding the movement in advanced performance, whilst maintaining a focus on the core movement mechanics. The opposing effect was found in explicit-based intervention. All three samples experienced a significant increase in reinvestment propensity directly following the explicit intervention. Novice participants showed an increase of approximately 20%, with experienced and professional showing an increase of 5% and 3% respectively in comparison to the control group. The propensity to reinvest increased as experience progressed, however it is arguable that this is not a reflection of the strength of the impacting effect from the intervention. This may be a reflection on the measurement scale used, as a ceiling effect may be possible as close to maximum scores were attained at baseline. More experienced individuals were exhibiting near maximum scores on the scale, therefore leaving minimal possibility to score higher as a result of the intervention.

This behaviour in reinvestment propensity compliments the results of performance measures notably. Superior, stable and robust performances via implicit means have been shown when exposed to stress from a myriad of research regarding various stressors (Diekfuss et al, 2018; Tse et al, 2017a; 2017b; Tzetzis & Lola, 2014; Schucker et al, 2013; Lam et al, 2009a; 2009b; Masters et al, 2008a; Poolton et al, 2007b; Liao & Masters, 2001). Attentional control theory (ACT) (Eysenck et al, 2007) attributes this to anxiety impairing attentional control and interaction of goal and stimulus driven systems (Yantis, 1998). These two systems are governed by the 'central executive' component of working memory (Baddeley, & Hitch, 1974). ACT predicts that the adversarial effect of anxiety will increase the attentional control, requiring more processing resources than are available (Eysenck et al, 2007). This

overwhelming effect is understood to impact the three main functions (responsible for attentional control) of the central executive; shifting, inhibition and updating (Miyake et al, 2000). The shifting and inhibition functions have been identified as the most important regarding attentional control as shifting is responsible for positive attentional control between relevant stimuli, and inhibition as the act of negative attentional control inhibiting distractor stimuli from interference (Derakshan & Eysenck, 2009; Eysenck et al, 2007).

Aron et al, (2004) has identified that utilising the shifting and updating functions engages a 'task set' defined as the ability to configure available processing resources to perform one cognitive task over another afforded by upcoming stimuli (Monsell et al, 2000). Moving between these task sets, incurs a 'switch cost' known as task set reconfiguration (TSR) and includes shifting attention between task stimuli, retrieval of task goals from memory or external cues and deleting no longer adequate responses via adjustments to the correct task response (Monsell, 2003).

Research on the effects of anxiety and TSR (specifically switching aspect) has shown reduced performance due to inherent cost of moving between multiple stimuli (Johnson, 2009; Derakshan et al, 2009; Ansari et al, 2008). This effect is echoed continuously throughout the finding of the current thesis. In all three skill acquisition based studies, performance was shown to be superior by those educated by less explicit means (implicit based learning). Thereby having less explicit stimuli to engage with and move between incurring a greater switching cost or more extensive task set reconfiguration demand. By utilising minimal explicit instructions (guided discovery) or even a single instructional stimuli (analogy), it may reduce the demand by limiting the switching aspect of attention control. It is this aspect of overwhelming working memory and

impairing attentional control that could allow for more implicit-based teaching methods to provide the superior performance shown under highly stressful demands. Derakshan et al (2009) concluded that TSR was impacted greater as task complexity increased. This further supports the results of the current thesis as this overwhelming effect is seen to impact even the more skilful professional athletes when task switching demands are high within the final study (chapter 6).

As mentioned previously, task set reconfiguration involves retrieval of task goals from memory or external cues and deleting no longer adequate responses via adjustments to the correct task response (Monsell, 2003). This is similar to the updating function of the working memory. The updating function is responsible for the overwriting of old information considered no longer relevant via active monitoring and manipulation of current information (Miyake et al, 2000; Morris & Jones; 1990). A small collection of research has found the updating function to be impaired by stress (Sorg & Withney, 1992; Drake, 1988), however ultimately the updating function is shown to be less effected by stress as a singular concept (see Eysenck et al, 2007 for a review). Fales et al (2010), examined neural activity and updating function under stressful conditions, finding no excess activity beyond the shifting function, suggesting the efficiency of the updating function is less effected by anxiety. This is understandable as the necessity to update can be arguably dependent on the prerequisite of obtaining new information acquired from switching between perceived stimuli. Research regarding the updating function have been inconsistent, but ultimately shows minor impact in studies involving stressful conditions or emotionally charged stimuli (see Eysenck et al, 2007).

The third and final function of the central executive is the inhibition function responsible for the repression of dominant, automatic, proponent responses or distracting stimuli (Friedman & Miyake, 2004; Miyake et al, 2000). Friedman & Miyake (2004), identified three main forms of inhibition; proactive interference (resistance to previous memory intrusions), proponent response inhibition (resistance to automatic responses), and distracter interference (ability to resist task irrelevant stimuli). The inhibition function has a large collection of research identifying this as a major contributor to the debilitating effect of working memory and subsequent attentional control of anxiety via threat (see Cisler & Koster, 2010 for a review). Primarily, this is induced by past memories or previous experiences of the threat. This influential effect of anxiety on the inhibition function of the working memory's central executive component is fundamental in the overall findings of the current thesis.

In high-risk sports the notion of severe injury is clearly apparent, and fear of injury has been shown to be present (Brymer & Schweitzer, 2012). Past experiences have been identified as being consciously accessible within high-risk sports (Way, 2012). It is understandable that any successful attempt at a skill in sport requires practice and subsequent failed attempts. Therefore, previous attempts will have occurred in other aspects despite the target skill identified within the current experiments of this thesis being novel to all performers. Considering this, these past memories of failure embody all three of the outlined forms of distraction. The attentional bias mechanisms regarding fear outlined in chapter 2 identify anxiety from fear of threat to be inherently instinctive and therefore automatic (prepotent response inhibition), whilst being obtained in the format of past memories (proactive memory interference). Finally, these detract attention away from the absolute goal which is performing



the target skill successfully (not failing/injury), essentially drawing attention to task irrelevant stimuli (distractor interference). As anxiety impairs the attentional control of the inhibition function, cognition will become more stimulus-driven and processing resources will be directed to task irrelevant stimuli (Eysenck et al, 2007). This may explain why the less explicitly driven stimuli educational techniques (e.g. analogy and guided discovery) were shown to provide a more effective performance as it allowed for the overwhelming effects of distracting memories present within anxiety and performance.

This notion of unsuccessful inhibition of both past memories and task irrelevant thoughts regarding injury from failure may also indirectly drive the strain placed on working memory from the other two functions (switching and updating) from task set reconfiguration (TSR). It was outlined earlier that the 'switch cost' from TSR can explain why less attentional demanding stimulus driven (implicit) strategies could be responsible for the superior performance of those groups. Similarly, the strain placed on the attentional load from failure to inhibit distracting stimuli may also attribute to the less attentionally demanding success of implicit-based practice. This does not explain the significantly higher reinvestment propensity of individuals engaging in high-risk sports through the initial study. Regardless of experience, or status, those engaged in high-risk sports scored significantly higher on reinvestment propensity than low-risk sport matched dependents. It should be noted that this study (experimental study 1) did not engage in any skill acquisition or education, but merely the overall disposition of those participating in high-risk sports were shown to reinvestment significantly greater within their movements.

Emotional regulation strategies have been identified to help aid in the moderation of attentional biases towards threat (Cisler & Koster, 2010). Emotional regulation has been related to the processes used to influence which emotions an individual may experience, when this may occur, and how they experience and express those (Gross, 1998). More importantly, attentional allocation has been proposed as a primary mechanism of emotional regulation (Koole, 2009; Gross, 2007; 2001; 1998). Purposeful attentional allocation towards neutral or positive stimuli has been shown to act as a form of purposeful distraction (Johnson, 2009; Dunning & Hajack, 2009; Sheppes & Meiran, 2008; van Dillen & Koole, 2007). In the case of high-risk sports, the end goal is to successfully perform the skill in the presence of risk. Way (2012) stipulated that the driving force is to perform successfully whilst going bigger and better every time, and the pursuit of pushing the danger limit and walking away that is the appealing aspect to the sport of skateboarding. Given the data obtained regarding reinvestment propensity, it is arguable that the attentional bias towards fear could be rerouted to the mechanics of the skill movements as a result to emotionally regulate said attention towards a successful approach within the sport. If this is the case, then the demands placed on working memory and the subsequent three functions of the central executive outlined earlier would be confounded to a greater extent. This concept would need to be clarified by understating further research.

The majority of this research has primarily attributed the behavioural results of the applied interventions through an information processing approach to learning. This is in most part due to the nature of reinvestment and its contributing effects on working memory (Baddeley, 2000). The key aspect of this thesis is the effect of physical harm or risk, and its effect on skill

acquisition. It is this factor that separates itself from previous research performed on physically safer sports. The assumption of implicit benefits whilst reinvesting within one's actions as a means of 'survival by success' is dependent on reinvestment theory and the subsequent impact on cognition, derived from an information processing perspective.

Despite this, one of the main aims of this thesis was to apply these learning interventions within an ecologically valid setting and thus, should at least consider the superior performance of individuals educated through implicit-based learning from an ecological perspective. An alternative approach to these findings can be viewed from theory of constraints (Newell, 1986). The theory proposes that it is the environment that places limitations on the learner to which they need to adapt within. An element that can positively influence the guidelines is acknowledgement and manipulation of task constraints during practice. "Task constraints are those constraints that are specific to the task being performed and are related to the goal of the task and the rules governing the task" (Glazier, 2017). According to McGinnis and Newell (1982), task constraints "are not physical, rather they are implied constraints or requirements which must be met within some tolerance range in order for the movement to produce a successful action" (p. 299). These can be in the form of spatial-temporal constraints (Correia, et al, 2012; Rosey et al, 2007), instructional constraints, (Newell & Ranganathan, 2010), and physical object constraints (Breslin et al, 2009; Stodden et al, 2006). Implementing these during practice trials supports Newell's ecological theory (1991) that emphasizes the relationship between the learner, the task, and the environment.

Research has examined specific sports regarded as action adventure sports and are defined as sports considered to involve high physical risk (Buckley, 2015). Immonen et al (2017) suggests that behaviours including movement production and subsequent learning are dependent on the demands that emerge from the interaction between the performer and environment.

Action adventure sports are not primarily controlled by organisational frameworks or regulated competitive structures (Ojala, 2015; Davids et al, 2013). This differentiates these kind of sports as they are not categorised by the same traditional concept of rule-based task constraints (Immonen et al, 2017). Aesthetic aspects such as personality of style (i.e. kinaesthetic personalisation whilst meeting task goal) and creativity (i.e. innovation, novelty and originality) are highly regarded in judging performance (Thorpe, 2017; Ojala, 2015; 2014). Research suggests that the functionality of skill within this sporting culture is dependent on the interaction between specific task and personal constraints such as collective agreement/interpretation and originality (Immonen et al, 2017).

Behavioural characteristics such as creativity and innovation impose crucial task constraints during performance and subsequent learning (Immonen et al, 2017). The superior learning within analogy-based interventions may be attributed to the allowance of creative freedom and innovation within the task constraints of less explicit means. Creativity has been identified as a key concept for action adventure sports of which skateboarding is regarded (Immonen et al, 2017). Implicit learning techniques (e.g. analogy learning) may provide differences in creative freedom and the subsequent affordances

required to perform. This will allow greater flexibility within the movement providing more opportunity for natural movement production as they are less explicitly prescriptive.

This flexibility has been demonstrated during complex skill acquisition of breaststroke in swimming by Komar et al (2014). They attributed the success of analogy-based education to the flexibility it offered to the participants as a means of tackling various task constraints proposed by the performers themselves and the environment. A multitude of high-risk sports are scored on a subjective basis (e.g. skateboarding, snowboarding, BMX, etc.) whereby execution is dependent on successful completion and visual style (Rodriguez, 2017). Given the complexity of these skills and the variety of individual performers (height, limb length, weight etc.) it is understandable that not all aspects of the skills can be ascertained from a singular prescriptive approach whereby 'one size fits all'. By allowing flexibility within the acquisition of movement parameters, it provided the learner to produce movements that considered natural to themselves and work within both the constraints and placed by themselves and the task.

The chosen design of the experimental studies within this thesis have attempted to prioritise the benefit of ecologically valid research. The skill acquisition based experimental studies (chapters 4-6) attempted to recreate the environment accurately from performance, surroundings and assessment techniques. By matching the research as accurately to the performance environment, this increases the external validity of the findings from subsequent reactive effects (Bryman, 2015). Often this is attained through sacrificing the experimental control, however attempts have been made to

minimise any loss of experimental control through the use of control groups, random allocation, and single blind design.

The use of subjective measurements is highly common within high-risk sports but can lack the academic objectivity required for experimental research. The use of kinematic analysis attempted to account for this void, in conjunction with the subjective analyses. The use of combining both subjective and objective measures within a single study is uncommon within the field of skill acquisition research. In future, research should attempt to implement both subjective and objective measures where possible, primarily when the professional assessment technique used within the target sport is subjective and particularly in ecologically valid settings.

The three experimental studies implemented substantial periods for acquisition and retention to account for temporal degradation. This can be uncommon in research as outlined in chapter 2, allowing for inconsistencies in research findings for skill acquisition. Future research should attempt to remain vigilant on the duration of such testing stages.

### *Future Recommendations*

Future research should aim to consider the qualitative attributes missing from the current thesis. The research findings may only be theoretically justified through logical support from research. Future research should be conducted from a qualitative, phenomenological respect to support the reliability and justify the validity of the current findings. Brymer & Schweitzer (2012) successfully examined the phenomena of fear/anxiety and risk extensively, and the use of such an approach towards risk and reinvestment would be highly beneficial as an extension to the current thesis' research perspective

Cisler & Koster (2010) identified that manipulating the cognitive load of an individual may provide vital understanding of the automaticity of attentional biases. Although this has been highlighted within the current thesis regarding working memory concepts (inhibition, shifting, updating), this understanding could be potentially developed further through conceptual training of attentional biases and anxiety. Research has shown the magnifying effect of anxiety by directing attention towards the bias (MacLeod et al, 2002), whilst facilitating attention away from threat may minimise symptoms (Amir et al, 2009; Amir et al, 2008). Threat intensity has been shown to moderate facilitated attention (Van Damme et al, 2006; Koster et al, 2006; 2005). Given that the current thesis' understanding of attending to threatening risk based on skill progression/succession, attempts to manipulate this bias may be beneficial in coping with the anxiety of these sports. By depleting cognitive resources with increased cognitive load, it may potentiate difficulty in disengagement, and/or attentional avoidance as these are linked to purposeful attempts to regulate affect (Cisler & Koster, 2010). The subsequent impact of training attentional biases in conjunction with various cognitive loads may determine how these biases may influence performance in high-risk sports.

### Conclusions

The current thesis aimed to explore the effect of risk and reinvestment upon skill acquisition within high-risk sports. This sporting population had yet to be examined, along with the use of fear of physical injury as the stimulus to induce stress. The originality of the current thesis stems from the identification of high-risk sports participants exhibiting higher propensity to reinvest within movement throughout novice to experienced and even further from amateur to

professional status. Research has yet to directly compare reinvestment in populations of sports regarding the risk classification of Zuckerman (1994).

Furthermore, research to date has failed to explore the use of skill acquisition techniques; analogy learning, guided discovery and explicit instruction across all levels of skill. The current research has shown that less consciously dependent learning techniques (analogy and guided discovery) provide an avenue for significantly superior learning and subsequent performance at all stages of learning. Performance measures of both a subjective and objective nature, identify significantly better performance, robust under stress and longer lasting. Coaching facilities of high-risk sports should aim to use implicit-based learning strategies for potentially engaged learning. Whilst many aspects of this thesis revealed significant differential effects, no major differences between the uses of live or video-based instructions were identified outright. This potentially allows coaches the use of either method for successful skill acquisition.

Finally, the current thesis utilised a skill consisting of whole-body, complex, gross movements, dependent on coordinating both upper and lower extremities simultaneously. Research to date (de Melker Worms et al, 2017; van Ginneken et al, 2017; Kinrade et al, 2010; Lam et al, 2009; Gucciardi & Dimmock, 2008) has relied on simple movement patterns with fine motor control utilising minimal coordination (e.g. card sorting, modified basketball free throw, table tennis serve, golf putting, darts). By examining this effectiveness with a complex, highly coordinated, whole body movement, this will provide the research field with greater ecological validity and practicability.



It is the inherent aspect of risk that separates these sports from the traditional lower risk counterparts. It should be emphasised that this expands beyond the chosen sport of skateboarding or realm of action sports. These sports are ever growing in popularity, emphasised by the recent induction of the upcoming Olympic games. Despite this, many other successful, less alternative sports such as high speed motor racing (e.g. Formula 1, Superbike, and NASCAR) could benefit from the implementation of the techniques shown to be superior from the current thesis. The findings may reach beyond sport and into, for example, surgical applications. Research has suggested an impact of self-monitoring focus within surgical trainee coaching applications (Timberlake, et al, 2018). The risk involved with successfully performing surgery is equally high and therefore stressful. Research has confirmed that surgeons display a high propensity to reinvest within their actions (Malhotra et al, 2012). The fact that the risk of physical threat from failure is aimed not on the surgeon, but the patient, has no effect on reducing the need for 'survival by success' as seen in the current thesis. The uncharted relationship between reinvestment and risk is shown by the current research as influential yet remains in its infancy. Future research should strive to develop this understanding. The benefits and progression of this large collection of high-risk sports will enable these unique, ever expanding culture to continually develop.

*"It is a matter of risk analysis. Anyone who has been fearless, hasn't been able to go on to achieve greatness. You assess the situation and perform the skill correctly; that is how you survive in these sports (high-risk). With consistent progression, the risk can only become greater"*

Dave Mirra (2012)

X-Games Gold Medallist (14x)

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**Appendix 1: Movement Specific Reinvestment Scale (Masters et al, 2005)****M.S.R.S.**

**DIRECTIONS:** Below are a number of statements about your movements. The possible answers go from 'strongly disagree' to 'strongly agree'. There are no right or wrong answers so circle the answer that best describes how you feel for each question.

**1) I rarely forget the times when my movements have failed me.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**2) I am always trying to figure out why my actions failed.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**3) I reflect about my movement a lot.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**4) I am always trying to think about my movements when I carry them out.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**5) I am self-conscious about the way I look when I am moving.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**6) I sometimes have the feeling that I am watching myself move.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**7) I am aware of the way my body works when I am carrying out a movement.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**8) I am concerned about my style of moving.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**9) If I see my reflection in a shop window, I will examine my movements.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**10) I am concerned about what people think about me when I am moving.**

strongly disagree	moderately disagree	weakly disagree	weakly agree	moderately agree	strongly agree
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**Appendix 2: Sensation Seeking Scale V (Zuckerman et al, 1978)****SSSV**

**DIRECTIONS:** Each of the items below contains two choices A and B. Please indicate which of the choices most describes your likes or the way you feel. The choices listed do not represent actions but rather intentions for actions which best fit your preferences. In some cases you may find items in which both choices describe your likes or feelings. Please choose the one which better describes your likes or feelings. In some cases you may find items which you do not like either choice. In these cases mark the choice you dislike least. Do not leave any items blank. It is important you respond to all items with only one choice, A or B. We are interested only in your likes or feelings, not in how others feel about these things or how one is supposed to feel. There are no right or wrong answers as in other kinds of tests. Be frank and give your honest appraisal of yourself.

- 1) A. I like "wild" uninhibited parties.  
B. I prefer quiet parties with good conversation.
- 2) A. There are some movies I enjoy seeing a second or even third time.  
B. I can't stand watching a movie that I've seen before.
- 3) A. I often wish I could be a mountain climber.  
B. I can't understand people who risk their necks climbing mountains.
- 4) A. I dislike body odours.  
B. I like some of the earthy body smells.
- 5) A. I get bored seeing the same old faces.  
B. I like the comfortable familiarity of everyday friends.
- 6) A. I like to explore a strange city or section of town myself, even if it means getting lost.  
B. I prefer a guide when I am in a place I don't know well.
- 7) A. I dislike people who do or say things just to shock or upset others.  
B. When you can predict almost everything a person will do and say he or she must be a bore
- 8) A. I usually don't enjoy a movie or play where I can predict what will happen in advance  
B. I don't mind watching a movie or play where I can predict what will happen in advance.

- 9) A. I have tried marijuana or would like to.  
B. I would never smoke marijuana.
- 10) A. I would not like to try any drug which might produce strange and dangerous effects on me.  
B. I would like to try some of the drugs that produce hallucinations.
- 11) A. A sensible person avoids activities that are dangerous.  
B. I sometimes like to do things that are a little frightening.
- 12) A. I dislike "swingers" (people who are uninhibited and free about sex)  
B. I enjoy the company of real "swingers".
- 13) A. I find that stimulants make me uncomfortable.  
B. I often like to get high (drinking liquor or smoking marijuana).
- 14) A. I like to try new foods that I have never tasted before.  
B. I order the dishes with which I am familiar so as to avoid disappointment and unpleasantness.
- 15) A. I enjoy looking at home movies, videos, or travel slides.  
B. Looking at someone's home movies, videos, or travel slides bores me tremendously.
- 16) A. I would like to take up the sport of water skiing.  
B. I would not like to take up the sport of water skiing.
- 17) A. I would like to try surfboard riding.  
B. I would not like to take up surfboard riding.
- 18) A. I would like to take off on a trip with no preplanned or definite routes, or timetable.  
B. When I go on a trip I like to plan my route and timetable fairly carefully.
- 19) A. I prefer the "down to earth" kinds of people as friends.  
B. I would like to make friends in some of the "far-out" groups like artists or "punks".
- 20) A. I would not like to learn to fly an aeroplane.  
B. I would like to learn to fly an aeroplane.
- 21) A. I prefer the surface of the water to the depths.  
B. I would like to go scuba diving.



- 22) A. I would like to meet some persons who are homosexual (men or women).  
B. I stay away from anyone I suspect of being "gay" or "lesbian".
- 23) A. I would like to try parachuting.  
B. I would never like to try jumping out of a plane, with or without a parachute.
- 24) A. I prefer friends who are excitingly unpredictable.  
B. I prefer friends who are reliable and predictable.
- 25) A. I am not interested in experience for its own sake.  
B. I like to have new and exciting experiences and sensations even if they are a little frightening, unconventional, or illegal.
- 26) A. The essence good art is in its clarity, symmetry of form, and harmony of colours.  
B. I often find beauty in the "clashing" of colours and irregular forms of modern paintings.
- 27) A. I enjoy spending time in the familiar surroundings of home.  
B. I get very restless if I have to stay around home for any length of time.
- 28) A. I like to dive off of the high board.  
B. I don't like the feeling I get of standing on the high board (or I don't go near it at all).
- 29) A. I like to date persons who are physically exciting.  
B. I like to date persons who share my values.
- 30) A. Heavy drinking usually ruins a party because some people get loud and boisterous.  
B. Keeping the drinks full is the key to a good party.
- 31) A. The worst social sin is to be rude.  
B. The worst social sin is to be a bore.
- 32) A. A person should have a considerable sexual experience before marriage.  
B. It's better if two married persons begin their sexual experience with each other.
- 33) A. Even if I had the money, I would not associate with flighty rich persons in the "jet set".  
B. I could conceive of myself seeking pleasures around the world with "jet set".
- 34) A. I like people who are sharp and witty even if they do sometimes insult others.  
B. I dislike people who have their fun at the expense of hurting the feelings of others.

- 35) A. There is altogether too much portrayal of sex in movies.  
B. I enjoy watching many of the “sexy” scenes in movies.
- 36) A. I feel best after taking a couple of drinks.  
B. Something is wrong with people who need liquor to feel good.
- 37) A. People should dress according to some standard of taste, neatness, and style.  
B. People should dress in individual ways even if the effects are sometimes strange.
- 38) A. Sailing long distances in small sailing crafts is foolhardy.  
B. I would like to sail a long distance in a small but seaworthy sailing craft.
- 39) A. I have no patience with dull or boring persons.  
B. I find something interesting in almost every person I talk to.
- 40) A. Skiing down a high mountain slope is a good way to end up on crutches.  
B. I think I would enjoy the sensations of skiing very fast down a high mountain slope.

**END OF TEST**

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**Appendix 3: Consent form****Consent Form****Researcher name:** Daniel Douglass**Project Title:**

I have read the enclosed participant information sheet and understand fully:

- My right to withdraw from the experiment at **any** given time/point throughout or after today without questioning
- The information provided is for further reference only and shall be dealt with for the sole purpose of the study
- All results will be held in the **strictest confidence** and no names or any other identifying information will be published. All participants will be represented by their group initial followed by participant number
- When the current study is finished, all documents will be disposed of confidentially.

and hereby agree to participate in the above experiment.

**Name:****Age:****Preferred Sport to participate within:****How long have you played your sport:****Years:****Months****Have you ever played your sport on a national / professional basis?****Signature:****Date:**

**Appendix 4: Instructions for Guided Discovery groups within experimental study 2 (“Ollie”)**

1. Stand with feet shoulder width apart
2. Keep one foot on the tail and the other halfway between the bolts
3. Crouch down, bending the knees whilst staying on your toes
4. Keep your hands down by your side
5. Jump upwards from the board, snapping the tail with your back-foot
6. Raise your arms up as you jump
7. Bring your knees up into your chest, keeping the board under you
8. Slide the side of your front-foot up along the deck
9. Aim to place the flat of your feet over each set of bolts
10. When landing, absorb the impact by bending your knees slowly

**Appendix 5: Instructions for Explicit learning groups within experimental study 2 (“Ollie”)**

1. Stand with feet shoulder width apart
2. Keep your back straight, with your chest up
3. Twist your back-foot back towards the tail of the deck
4. Keep one foot on the tail and the other halfway between the bolts
5. Crouch down, bending the knees whilst staying on your toes
6. Maintain posture keeping your back straight, and your head in line with the board
7. Keep your hands down by your side
8. Shift your weight onto your back foot
9. Jump upwards from the board, snapping the tail with your back-foot
10. Centre your weight back towards your front foot

11. Raise your arms up as you jump
12. When lifting your arms up, go no higher than level with your shoulders
13. Bring your knees up into your chest, keeping the board under you
14. Maintain this movement until the desired height is achieved
15. Slide the side of your front-foot up along the deck
16. Aim to place the flat of your feet over each set of bolts
17. When landing, absorb the impact by bending your knees slowly
18. Bring your arms down slowly
19. Keep your head upright, over the board
20. Be sure to keep looking over your forward facing shoulder throughout the movement

**Appendix 6: Instructions for Explicit learning groups within experimental study 3**

**("Backside 180 Kickflip")**

1. Stand with you back foot on the tail of the deck
2. Your front foot should be positioned with toes about an inch behind the front concave of the deck.
3. Bend you knees, keeping your head over the board
4. Rotate your shoulders and hips away from the backside direction
5. Your leading arm should be straight out, eventually coming straight out to the side
6. Your trailing arm should aim to bend at the elbow and point in the same direction
7. Initiate the snap, with your back foot, whilst releasing from your wind up
8. Rotate your head round as fast as possible to spot your landing

9. Your spin should be initiated from your head down, through your shoulders and hips
10. Rotate 180 degrees so that the tail of the board is now leading
11. Keep your eyes up and spot your landing, do not watch your board
12. Drag your front foot diagonally up through the deck
13. Aim for the front concave and flick your toes to initiate the board spin
14. Lift your back foot up keeping it flat to receive the catch
15. Keep your arms straight and at shoulder height
16. Wait for the board to spin into you back foot to catch it
17. Bring your front foot up, outwards and over the board
18. When landing, absorb the impact by bending your knees slowly
19. Bring your arms down slowly
20. Keep your head upright, over the board looking over your forward facing shoulder

**Appendix 7: Instructions for Explicit learning groups within experimental study 4 (“360 Nollie Laserflip”)**

1. Stand with you front foot on the nose of the deck
2. Your back foot should be positioned with toes about an inch behind the back concave of the deck.
3. Bend you knees, keeping your head over the board
4. Rotate your shoulders and hips away from the backside direction
5. Your leading arm should be straight out, eventually coming straight out to the side
6. Your trailing arm should aim to bend at the elbow and point in the same direction

7. Initiate the snap, with your front foot, whilst releasing from your wind up
8. Your spin should be initiated from your head down, through your shoulders and hips
9. Rotate 360 degrees so that you are facing the same way as starting
10. Rotate your head as quickly as possible to drive your shoulders around to follow
11. Push the heel of your back foot diagonally through the deck in a towards motion initiating the heelflip
12. Whilst performing this, kick the heel of your front foot straight forward to start the rotation of the board
13. A key aspect of this trick is to push the board in front of you
14. You should expect to jump forwards in order to catch the board
15. After manipulating the board, tuck both knees up into your chest out of the way
16. Allow the board to complete 2 variable rotations before push both feet towards the board
17. The aim should be to land both feet above the bolts for a reliable landing
18. As your leading shoulder is entering the final half of the spin you should be spotting your landing
19. Upon both feet coming into contact with the board, push the board down towards the ground
20. When landing you should compress yourself downwards, absorbing the impact with your legs through your knees